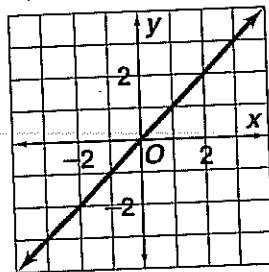


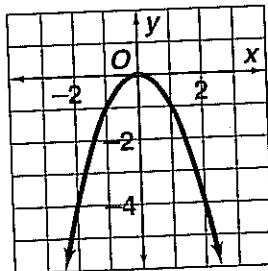
DIAGNOSING READINESS

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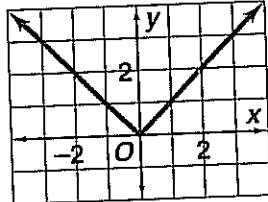
1. $2a - b^2 + c$ for $a = -1, b = 3, c = -2$: $2(-1) - 3^2 + (-2) = -2 - 9 - 2 = -13$
2. $\frac{c^2 - ab}{2a}$ for $a = -1, b = 3, c = -2$: $\frac{(-2)^2 - (-1)(3)}{2(-1)} = \frac{4 - (-3)}{-2} = -\frac{7}{2}$
3. $bc - 3a^2$ for $a = -1, b = 3, c = -2$: $3(-2) - 3(-1)^2 = -6 - 3(1) = -6 - 3 = -9$
4. $\frac{b^2 - 4ac}{2a}$ for $a = -1, b = 3, c = -2$: $\frac{3^2 - 4(-1)(-2)}{2(-1)} = \frac{9 - 8}{-2} = -\frac{1}{2}$
5. $5a + 2b(c - 1)$ for $a = -1, b = 3, c = -2$: $5(-1) + 2(3)(-2 - 1) = -5 + 6(-3) = -5 - 18 = -23$
6. $c^2 + 2ab - 1$ for $a = -1, b = 3, c = -2$: $(-2)^2 + 2(-1)(3) - 1 = 4 - 6 - 1 = -3$
7. $f(x) = -3x^2$; $f(-6) = -3(-6)^2 = -3(36) = -108$
8. $y = x^2 - 10$ for $x = -6$: $y = (-6)^2 - 10 = 36 - 10 = 26$
9. $h(x) = x^2 + 6x$; $h(-6) = (-6)^2 + 6(-6) = 36 - 36 = 0$
10. $y = (x - 1)^2$ for $x = -6$: $y = (-6 - 1)^2 = (-7)^2 = 49$
11. $y = 5 - 2x^2$ for $x = -6$: $5 - 2(-6)^2 = 5 - 72 = -67$
12. $y = (1 + x)^2$ for $x = -6$: $y = (1 + (-6))^2 = (-5)^2 = 25$
13. $g(x) = \frac{2}{3}x^2$; $g(-6) = \frac{2}{3}(-6)^2 = \frac{2}{3}(36) = 24$
14. $y = (2x)^2$ for $x = -6$: $y = (2(-6))^2 = (-12)^2 = 144$
15. $y = x$



16. $y = -x^2$



17. $y = |x|$



18. $(x + 2)(x - 3) = x^2 - 3x + 2x - 6 = x^2 - x - 6$
19. $(2y + 1)(2y + 3) = (2y)^2 + 3(2y) + 1(2y) + 3 = 4y^2 + 6y + 2y + 3 = 4y^2 + 8y + 3$
20. $(3x - 7)(x + 4) = 3x^2 + 4(3x) - 7x - 28 = 3x^2 + 12x - 7x - 28 = 3x^2 + 5x - 28$

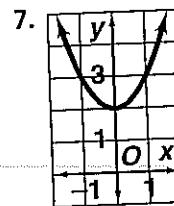
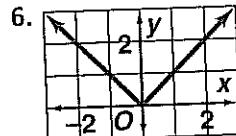
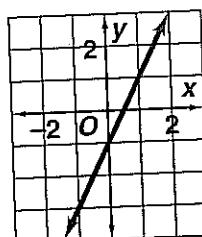
3. $3x^2 + 5x - 28$
21. $4x^2 + 4x + 1 = (2x)^2 + 2(2x)(1) + 1^2 = (2x + 1)^2$
22. $5x^2 + 32x - 21 = (5x - 3)(x + 7)$
23. $8x^2 - 10x + 3 = (4x - 3)(2x - 1)$
24. $m^2 - 7m - 18 = (m - 9)(m + 2)$
25. $12y^2 + 8y - 15 = (6y - 5)(2y + 3)$
26. $x^2 - 18x + 81 = x^2 - 2(9)x + 9^2 = (x - 9)^2$

10-1 Exploring Quadratic Graphs

pages 510–516

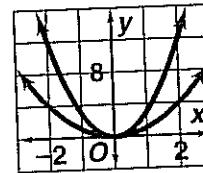
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1. -24 2. 18 3. 12 4. 35



Investigation 1. $y = x^2$, $y = 3x^2$

- 2–4. Answers may vary.
Samples are given.

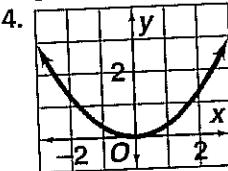


- 2a. Both graphs are U-shaped with the lowest points at the origin.

- 2b. $y = 3x^2$ is narrower than $y = x^2$.

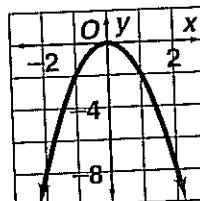
3. $y = \frac{1}{3}x^2$ will be U-shaped with its lowest point at the origin. It will be wider than $y = x^2$.

- 4.
- Yes; the graph is wider than $y = x^2$.



Check Understanding 1a. The vertex is $(4, 3)$; it is a maximum. 1b. The vertex is $(-3, -3)$; it is a minimum.

x	$f(x) = -2x^2$	(x, y)
0	$-2(0)^2 = 0$	$(0, 0)$
1	$-2(1)^2 = -2$	$(1, -2)$
2	$-2(2)^2 = -8$	$(2, -8)$



3. widest to narrowest graph: $y = \frac{1}{2}x^2$, $y = x^2$, $y = -2x^2$

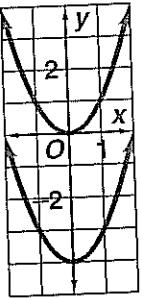
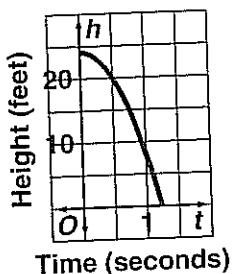
4a. $y = x^2$, $y = x^2 - 4$

The graph of $y = x^2 - 4$ has the same shape as the graph of $y = x^2$, but it is shifted down 4 units.

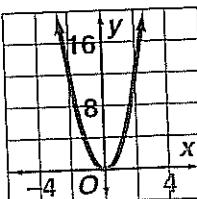
4b. Positive values of c shift the vertex up. Negative values of c shift the vertex down.

$$5a. h = -16t^2 + 24$$

5b. Time must be nonnegative.



x	$f(x) = 3x^2$	(x, y)
0	$3(0)^2 = 0$	$(0, 0)$
1	$3(1)^2 = 3$	$(1, 3)$
2	$3(2)^2 = 12$	$(2, 12)$



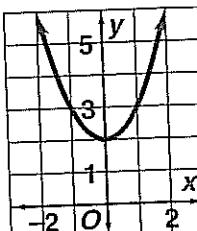
10. widest to narrowest graph:

$y = \frac{1}{2}x^2$, $y = 3x^2$, $y = 4x^2$

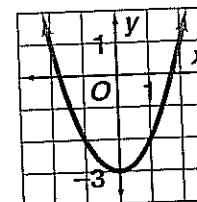
11. widest to narrowest graph: $f(x) = \frac{1}{3}x^2$, $f(x) = x^2$, $f(x) = 5x^2$ 12. widest to narrowest graph: $y = -\frac{1}{4}x^2$, $y = -\frac{1}{2}x^2$, $y = 5x^2$ 13. widest to narrowest graph:

$f(x) = -\frac{2}{3}x^2$, $f(x) = -2x^2$, $f(x) = -4x^2$

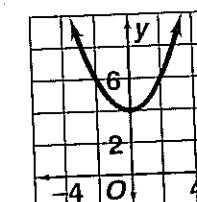
14. $f(x) = x^2 + 2$; same as $f(x) = x^2$, but shifted up 2 units



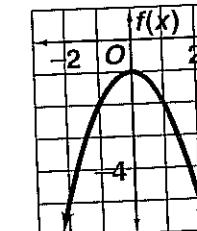
15. $y = x^2 - 3$; same as $y = x^2$, but shifted down 3 units



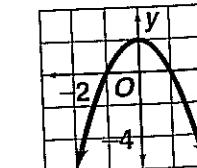
16. $y = \frac{1}{2}x^2 + 4$; same as $y = \frac{1}{2}x^2$, but shifted up 4 units



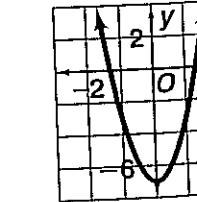
17. $f(x) = -x^2 - 1$; same as $f(x) = -x^2$, but shifted down 1 unit



18. $y = -2x^2 + 2$; same as $y = -2x^2$, but shifted up 2 units



19. $f(x) = 4x^2 - 7$; same as $f(x) = 4x^2$, but shifted down 7 units

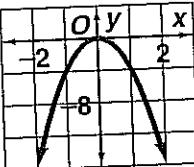


Exercises 1. The vertex is $(2, 5)$; it is a maximum.

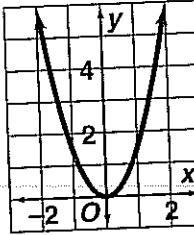
2. The vertex is $(-3, -2)$; it is a minimum.

3. The vertex is $(2, 1)$; it is a minimum.

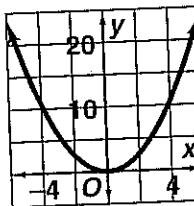
x	$y = -4x^2$	(x, y)
0	$-4(0)^2 = 0$	$(0, 0)$
1	$-4(1)^2 = -4$	$(1, -4)$
2	$-4(2)^2 = -16$	$(2, -16)$



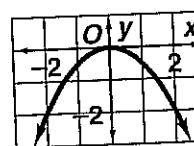
x	$f(x) = 1.5x^2$	(x, y)
0	$1.5(0)^2 = 0$	$(0, 0)$
1	$1.5(1)^2 = 1.5$	$(1, 1.5)$
2	$1.5(2)^2 = 6$	$(2, 6)$



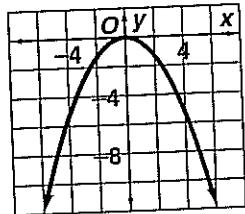
x	$y = \frac{2}{3}x^2$	(x, y)
0	$\frac{2}{3}(0)^2 = 0$	$(0, 0)$
2	$\frac{2}{3}(2)^2 = \frac{8}{3}$	$(2, \frac{8}{3})$
4	$\frac{2}{3}(4)^2 = \frac{32}{3}$	$(4, \frac{32}{3})$
6	$\frac{2}{3}(6)^2 = 24$	$(6, 24)$



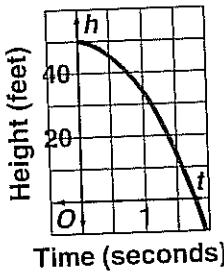
x	$f(x) = -\frac{1}{2}x^2$	(x, y)
0	$-\frac{1}{2}(0)^2 = 0$	$(0, 0)$
1	$-\frac{1}{2}(1)^2 = -\frac{1}{2}$	$(1, -\frac{1}{2})$
2	$-\frac{1}{2}(2)^2 = -2$	$(2, -2)$



x	$y = -\frac{1}{3}x^2$	(x, y)
0	$-\frac{1}{3}(0)^2 = 0$	$(0, 0)$
2	$-\frac{1}{3}(2)^2 = -\frac{4}{3}$	$(2, -\frac{4}{3})$
4	$-\frac{1}{3}(4)^2 = -\frac{16}{3}$	$(4, -\frac{16}{3})$
6	$-\frac{1}{3}(6)^2 = -12$	$(6, -12)$

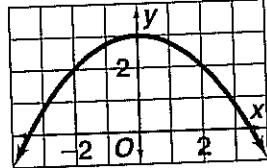


0. $h = -16t^2 + 50$

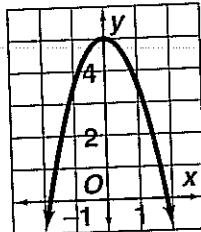


21. The parabola opens downward, so choose C, E, or F.
The graph is shifted up 8 units, so choose E.
22. The parabola opens upward, so choose A, B, or D.
The graph is shifted down 1 unit, so choose A.
23. The parabola opens downward, so choose C, E, or F.
The graph is shifted up 5 units, so choose F.
24. The parabola opens upward, so choose A, B, or D.
The graph is shifted up 4 units, so choose B.
25. The parabola opens downward, so choose C, E, or F.
The graph is shifted up 2 units, so choose C.
26. The parabola opens upward, so choose A, B, or D.
The graph is shifted down 5 units, so choose D.
27. The graph of $y = 2x^2$ is narrower.
28. The graph of $y = -x^2$ opens downward.
29. The graph of $y = 1.5x^2$ is narrower.
30. The graph of $y = \frac{1}{2}x^2$ is wider.

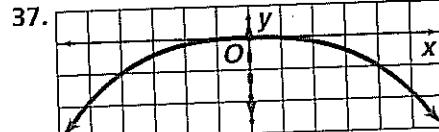
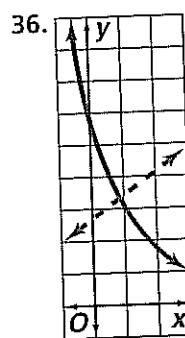
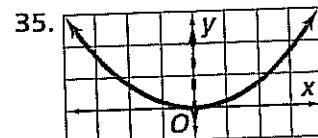
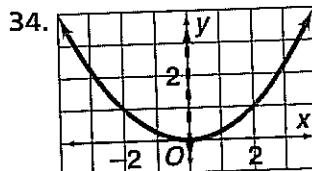
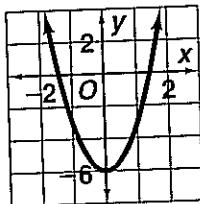
31. $y = -\frac{1}{4}x^2 + 3$;
same as $y = -\frac{1}{4}x^2$,
but shifted up 3 units



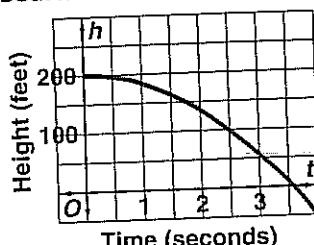
32. $f(x) = -1.5x^2 + 5$;
same as $f(x) = -1.5x^2$,
but shifted up 5 units



33. $y = 3x^2 - 6$;
same as $y = 3x^2$,
but shifted down 6 units



38a. $h = -16t^2 + 200$

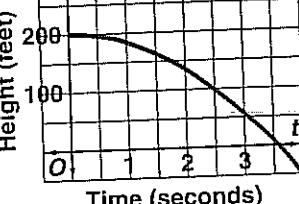


38b. $h = -16(1)^2 + 200 =$

184; 184 ft

38c. $h = -16(3)^2 + 200 =$

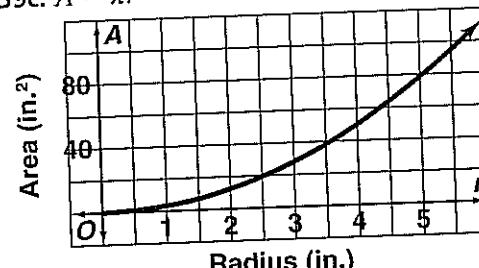
56; 56 ft



39a. The diameter of the pizza must be less than 12 in., so the radius must be less than 6 in.; $0 < r < 6$

39b. If $r = 6$, $A = \pi \cdot 6^2 = 36\pi$, so A must be less than 36π ; $0 < A < 36\pi \approx 113.1$

39c. $A = \pi r^2$



40. $a > 0$, so the parabola opens upward; K, L

41. $a < 0$, so the parabola opens downward; M

42. $|a|$ has the greatest value, so the graph is the narrowest; K 43. $|a|$ has the least value, so the graph is the widest; M 44. Answers may vary. Samples are given.

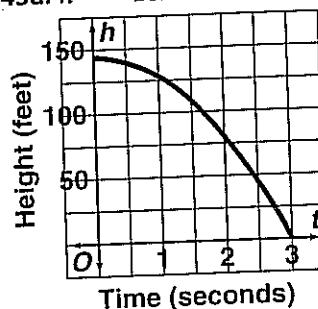
44a. $y = 5x^2$ 44b. $y = -5x^2$ 44c. $y = 3x^2$

45a. $h = -16t^2 + 144$

45b. 16 ft

45c. No; the apple falls

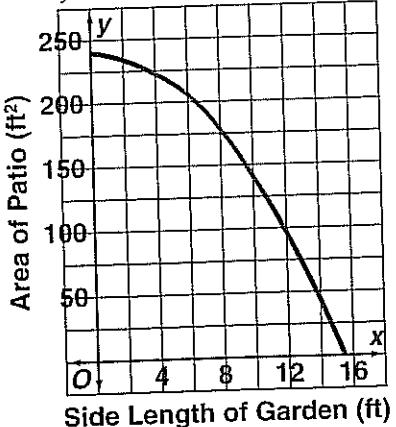
48 ft from $t = 1$ to $t = 2$, because it is accelerating.



46a. The graph of $y = ax^2 + c$ intersects the x-axis in two places when $c \neq 0$ and a and c have opposite signs.

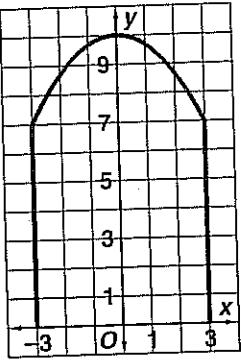
46b. The graph of $y = ax^2 + c$ does not intersect the x-axis when $c \neq 0$ and a and c have the same signs.

47a. $y = 240 - x^2$

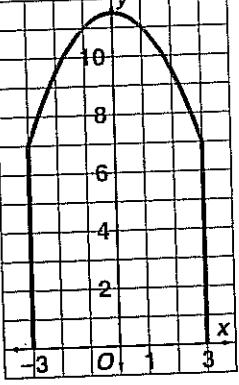


48a. $a > 0$ 48b. $|a| > 1$

49a.



49b.



50. $|-3| > |2|$, so the answer is B. 51. The graph of $y = -2x^2 - 1$ crosses the y -axis at -1 ; look for a c -value ($y = ax^2 + c$) that is less than -1 ; $y = 3x^2 - 3$, so the answer is G.

52. Test each point in the equation $y = 4x^2 + 3$.

A. $(0, 3); 3 \stackrel{?}{=} 4(0)^2 + 3, 3 = 3$

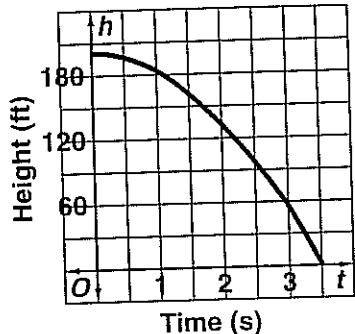
B. $(1, 7); 7 \stackrel{?}{=} 4(1)^2 + 3, 7 = 7$

C. $(-1, 7); 7 \stackrel{?}{=} 4(-1)^2 + 3, 7 = 7$

D. $(3, 27); 27 \stackrel{?}{=} 4(3)^2 + 3, 27 \neq 39$; the answer is D.

53. [4] 53a.

t	$h = -16t^2 + 200$	(t, h)
0	$-16(0)^2 + 200 = 200$	$(0, 200)$
1	$-16(1)^2 + 200 = 184$	$(1, 184)$
2	$-16(2)^2 + 200 = 136$	$(2, 136)$
3	$-16(3)^2 + 200 = 56$	$(3, 56)$
4	$-16(4)^2 + 200 = -56$	$(4, -56)$



53b. When $h = 0, t \approx 3.5$; about 3.5 seconds
 [3] estimate incorrect or missing
 [2] error in table or graph
 [1] table OR reasonable graph only

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

47b. $0 < x < 12$; the side length of the square garden must be less than the width of the patio.

47c. $96 < A < 240$; as the side length of the garden increases from 0 to 12, the area of the patio decreases from 240 to 96.

47d. about 6 ft

55. $15a^3 - 18a^2 - 10a + 12 = 3a^2(5a - 6) - 2(5a - 6) = (3a^2 - 2)(5a - 6)$ 56. $7b^3 + 14b^2 + b + 2 = 7b^2(b + 2) + 1(b + 2) = (7b^2 + 1)(b + 2)$
 57. $y^3 + 3y^2 - 4y - 12 = y^2(y + 3) - 4(y + 3) = (y^2 - 4)(y + 3) = (y + 2)(y - 2)(y + 3)$
 58. $2n^3 - 2n^2 - 24n = 2n(n^2 - n - 12) = 2n(n + 3)(n - 4)$ 59. $30m^3 + 51m^2 + 9m = 3m(10m^2 + 17m + 3) = 3m(2m + 3)(5m + 1)$
 60. $5x(3x - 4) = 15x^2 - 20x$ 61. $(n - 7)9n = 9n^2 - 63n$ 62. $-2t^2(6t - 11) = -12t^3 + 22t^2$
 63. $4m^2(3m^4 - m^3 + 5) = 12m^6 - 4m^5 + 20m^2$
 64. $-5y(3y^5 + 2y^3 - 4) = -15y^6 - 10y^4 + 20y$
 65. $3c^3(-4c^2 + 7c - 8) = -12c^5 + 21c^4 - 24c^3$
 66. $(2 - 0.2)x = 27; 1.8x = 27; x = 15$; 15 balloons

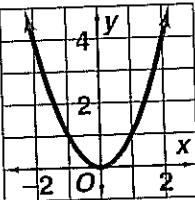
10-2 Quadratic Functions

pages 517–522

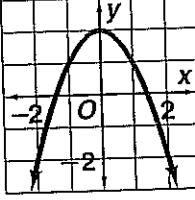
Check Skills You'll Need For complete solutions see Daily Skills Check and Lesson Quiz Transparencies or Presentation Pro CD-ROM.

1. $\frac{1}{3}$ 2. $-\frac{2}{3}$ 3. $-3\frac{1}{2}$ 4. 6

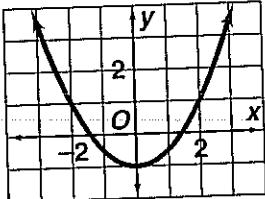
5.



6.



7.



Check Understanding 1. $f(x) =$

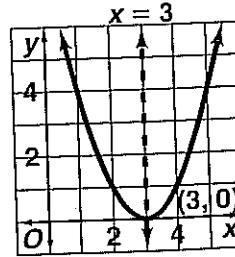
$x^2 - 6x + 9$; axis of symmetry:

$x = -\frac{b}{2a} = -\frac{-6}{2(1)} = 3, x = 3$;

y-coordinate of vertex:

$y = 3^2 - 6(3) + 9 = 0$;

vertex $(3, 0)$; points $(1, 4), (5, 4)$



2a. $h = -16t^2 + 48t + 4; t = -\frac{b}{2a} = -\frac{48}{2(-16)} = 1.5$;

1.5 seconds 2b. $h = -16(1.5)^2 + 48(1.5) + 4 = 40$; 40 ft

3a. $y \leq x^2 + 2x - 5$; boundary curve

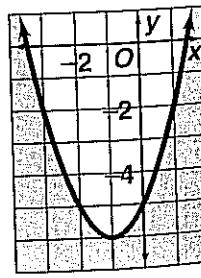
$y = x^2 + 2x - 5$; axis of symmetry:

$x = -\frac{b}{2a} = -\frac{2}{2(1)} = -1, x = -1$;

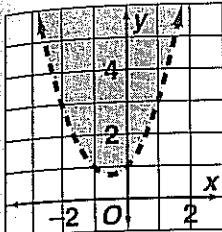
y-coordinate of vertex:

$y = (-1)^2 + 2(-1) - 5 = -6$;

vertex $(-1, -6)$; solid line and shade below



- 3b. $y > x^2 + x + 1$; boundary curve $y = x^2 + x + 1$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{1}{2(1)} = -\frac{1}{2}$, $x = -\frac{1}{2}$; y-coordinate of vertex: $y = \left(-\frac{1}{2}\right)^2 + \left(-\frac{1}{2}\right) + 1 = \frac{3}{4}$; vertex $\left(-\frac{1}{2}, \frac{3}{4}\right)$; dashed line and shade above



Exercises 1. $y = 2x^2 + 4$, or $y = 2x^2 + 0x + 4$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{0}{2(2)} = 0$, $x = 0$; y-coordinate of vertex: $y = 2(0)^2 + 4 = 4$; vertex $(0, 4)$ 2. $f(x) = 2x^2 + 4x - 5$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{4}{2(2)} = -1$, $x = -1$; y-coordinate of vertex: $y = 2(-1)^2 + 4(-1) - 5 = -7$; vertex $(-1, -7)$ 3. $y = x^2 - 8x - 9$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-8}{2(1)} = 4$, $x = 4$; y-coordinate of vertex: $y = 4^2 - 8(4) - 9 = -25$; vertex $(4, -25)$ 4. $y = 3x^2 - 9x + 5$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-9}{2(3)} = 1.5$, $x = 1.5$; y-coordinate of vertex: $y = 3(1.5)^2 - 9(1.5) + 5 = -1.75$; vertex $(1.5, -1.75)$

5–10. A. $y = x^2 - 6x$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-6}{2(1)} = 3$, $x = 3$, and parabola opens upward, so Ex. 9.

B. $y = x^2 + 6x$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{6}{2(1)} = -3$, $x = -3$, and parabola opens upward, so Ex. 5.

C. $y = -x^2 - 6x$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-6}{2(-1)} = -3$, $x = -3$, and parabola opens downward, so Ex. 7.

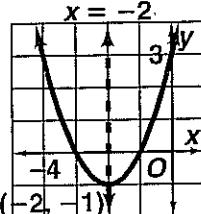
D. $y = -x^2 + 6x$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{6}{2(-1)} = 3$, $x = 3$, and parabola opens downward, so

Ex. 10. E. $y = -x^2 + 6$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{0}{2(-1)} = 0$, $x = 0$, and parabola opens downward, so

Ex. 6. F. $y = x^2 - 6$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{0}{2(1)} = 0$, $x = 0$, and parabola opens upward, so Ex. 8.

5. B 6. E 7. C 8. F 9. A 10. D

11. $f(x) = x^2 + 4x + 3$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{4}{2(1)} = -2$, $x = -2$; y-coordinate of vertex: $y = (-2)^2 + 4(-2) + 3 = -1$; vertex $(-2, -1)$; points $(0, 3), (-4, 3)$



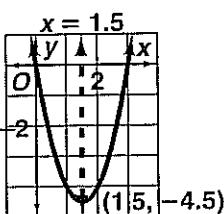
12. $y = 2x^2 - 6x$; axis of symmetry:

$x = -\frac{b}{2a} = -\frac{-6}{2(2)} = 1.5$, $x = 1.5$;

y-coordinate of vertex:

$y = 2(1.5)^2 - 6(1.5) = -4.5$;

vertex $(1.5, -4.5)$; points $(0, 0), (4, 0)$



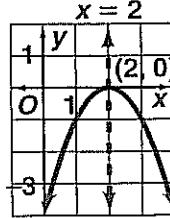
13. $y = -x^2 + 4x - 4$; axis of symmetry:

$x = -\frac{b}{2a} = -\frac{4}{2(-1)} = 2$, $x = 2$;

y-coordinate of vertex: $y =$

$-2^2 + 4(2) - 4 = 0$; vertex $(2, 0)$;

points $(0, -4), (4, -4)$



14. $y = 2x^2 + 3x + 1$; axis of symmetry:

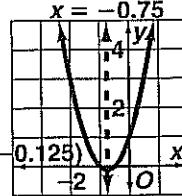
$x = -\frac{b}{2a} = -\frac{3}{2(2)} = -0.75$, $x = -0.75$;

y-coordinate of vertex: $y =$

$2(-0.75)^2 + 3(-0.75) + 1 = (-0.75, -0.125)$;

vertex $(-0.75, -0.125)$;

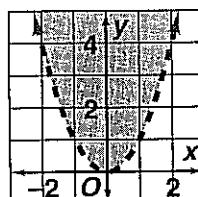
points $(0, 1), (-2, 3)$



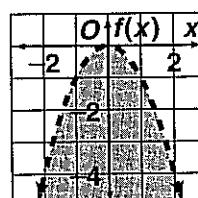
15a. $A = 40x - x^2$, or $A = -x^2 + 40x$; $x = -\frac{b}{2a} = -\frac{40}{2(-1)} = 20$; 20 ft 15b. $A = 40(20) - 20^2 = 400$; 400 ft²

16a. $h = -16t^2 + 40t + 6$; $t = -\frac{b}{2a} = -\frac{40}{2(-16)} = 1.25$; 1.25 s 16b. $h = -16(1.25)^2 + 40(1.25) + 6 = 31$; 31 ft

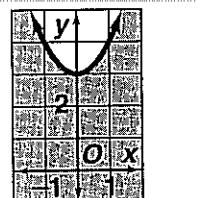
17. $y > x^2$; boundary curve $y = x^2$; dashed line and shade above



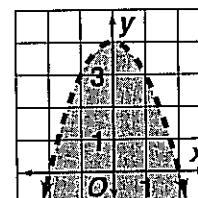
18. $f(x) < -x^2$; boundary curve $y = -x^2$; dashed line and shade below



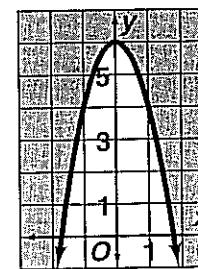
19. $y \leq x^2 + 3$; boundary curve $y = x^2 + 3$, same as $y = x^2$ but shifted up 3 units; solid line and shade below



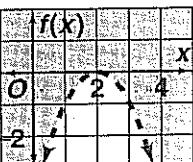
20. $y < -x^2 + 4$; boundary curve $y = -x^2 + 4$, same as $y = -x^2$ but shifted up 4 units; dashed line and shade below



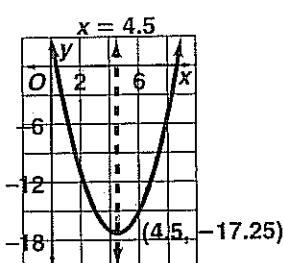
21. $y \geq -2x^2 + 6$; boundary curve $y = -2x^2 + 6$, same as $y = -2x^2$ but shifted up 6 units; solid line and shade above



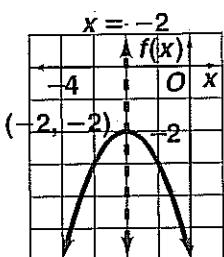
22. $f(x) > -x^2 + 4x - 4$; boundary curve $y = -x^2 + 4x - 4$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{4}{2(-1)} = 2$, $x = 2$; y-coordinate of vertex: $y = -2^2 + 4(2) - 4 = 0$; vertex $(2, 0)$; points $(3, -1), (1, -1)$; dashed line and shade above



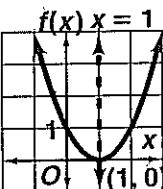
23. $y = x^2 - 9x + 3$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-9}{2(1)} = 4.5$, $x = 4.5$; y-coordinate of vertex: $y = 4.5^2 - 9(4.5) + 3 = -17.25$; vertex $(4.5, -17.25)$; points $(0, 3), (6, -15)$



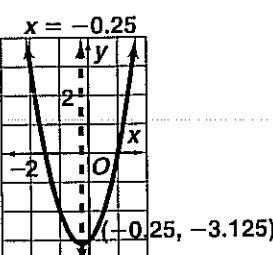
24. $f(x) = -x^2 - 4x - 6$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-4}{2(-1)} = -2$, $x = -2$; y-coordinate of vertex: $y = -(-2)^2 - 4(-2) - 6 = -2$; vertex $(-2, -2)$; points $(0, -6), (-4, -6)$



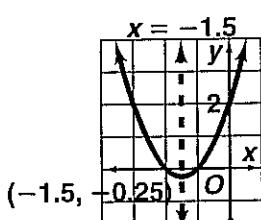
25. $f(x) = x^2 - 2x + 1$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-2}{2(1)} = 1$, $x = 1$; y-coordinate of vertex: $y = 1^2 - 2(1) + 1 = 0$; vertex $(1, 0)$; points $(0, 1), (2, 1)$



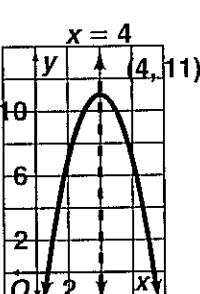
26. $y = 2x^2 + x - 3$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{1}{2(2)} = -0.25$, $x = -0.25$; y-coordinate of vertex: $y = 2(-0.25)^2 + (-0.25) - 3 = -3.125$; vertex $(-0.25, -3.125)$; points $(1, 0), (-1, -2)$



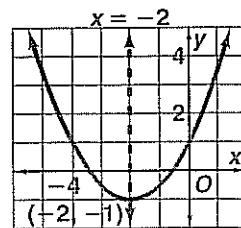
27. $y = x^2 + 3x + 2$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{3}{2(1)} = -1.5$, $x = -1.5$; y-coordinate of vertex: $y = (-1.5)^2 + 3(-1.5) + 2 = -0.25$; vertex $(-1.5, -0.25)$; points $(0, 2), (-3, 2)$



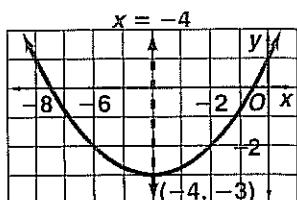
28. $y = -x^2 + 8x - 5$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{8}{2(-1)} = 4$, $x = 4$; y-coordinate of vertex: $y = -4^2 + 8(4) - 5 = 11$; vertex $(4, 11)$; points $(1, 2), (5, 10)$



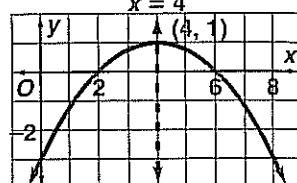
29. $y = \frac{1}{2}x^2 + 2x + 1$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{2}{2(\frac{1}{2})} = -2$, $x = -2$; y-coordinate of vertex: $y = \frac{1}{2}(-2)^2 + 2(-2) + 1 = -1$; vertex $(-2, -1)$; points $(0, 1), (-4, 1)$



30. $y = \frac{1}{4}x^2 + 2x + 1$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{2}{2(\frac{1}{4})} = -4$, $x = -4$; y-coordinate of vertex: $y = \frac{1}{4}(-4)^2 + 2(-4) + 1 = -3$; vertex $(-4, -3)$; points $(0, 1), (-8, 1)$



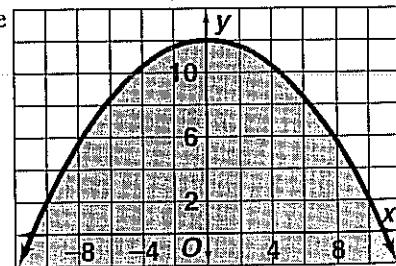
31. $y = -\frac{1}{4}x^2 + 2x - 3$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{2}{2(-\frac{1}{4})} = 4$, $x = 4$; y-coordinate of vertex: $y = -\frac{1}{4}(4)^2 + 2(4) - 3 = 1$; vertex $(4, 1)$; points $(0, -3), (8, -3)$



32–34. Answers may vary. Samples are given.

32. $y = 2x^2 - 8x + 1$ 33. $y = -3x^2$ 34. $y = 2x^2 + 4$
35a. $y = -2.2x^2 + 5.3x + 4$; $x = -\frac{b}{2a} = -\frac{5.3}{2(-2.2)} \approx 1.2$; about 1.2 meters 35b. $y = -2.2(1.2)^2 + 5.3(1.2) + 4 = 7.192 \approx 7.2$; about 7.2 meters 36a. $y \leq -0.1x^2 + 12$

36b. boundary curve $y = -0.1x^2 + 12$; points $(0, 12), (6, 8.4), (10, 2), (-6, 8.4), (-10, 2)$



36c. Yes; when $x = 6$, $y = 8.4$, so the camper will fit.

37a. $S = -64p^2 + 1600p$; $p = -\frac{b}{2a} = -\frac{1600}{2(-64)} = 12.5$; \$12.50 37b. $S = -64(12.5)^2 + 1600(12.5) = 10,000$; \$10,000 38. Area ≈ 32 units 2 39. Area ≈ 26 units 2

40. Answers may vary. Sample: If the coefficient of the squared term is positive, the vertex is a minimum; if it is negative, the vertex is a maximum. 41. Answers may vary. Sample: a affects whether the parabola opens up or down, b affects the axis of symmetry, and c affects the y -intercept.

42a. $2(w + \ell) = 26$; $w + \ell = 13$; $w = 13 - \ell$
42b. $A = \ell w = \ell(13 - \ell) = 13\ell - \ell^2 = -\ell^2 + 13\ell$; $A = -\ell^2 + 13\ell$ 42c. $\ell = -\frac{b}{2a} = -\frac{13}{2(-1)} = 6.5$; $A = -6.5^2 + 13(6.5) = 42.25$, vertex $(6.5, 42.25)$
42d. $\ell = 6.5$, so $w = 13 - 6.5 = 6.5$; 6.5 ft by 6.5 ft

43a. $h = -4.9t^2 + 3.82t + 1.7$; $t = -\frac{b}{2a} =$

$-\frac{3.82}{2(-4.9)} \approx 0.4$; about 0.4 seconds 43b. $h =$

$-4.9(0.6)^2 + 3.82(0.6) + 1.7 \approx 2.23$; no, because at 0.6 seconds the ball has a height of about 2.23 m, but the net has a height of 2.43 m

44. ① $y \geq -x^2 + 6$; boundary curve $y = -x^2 + 6$, parabola that opens downward with vertex $(0, 6)$ and points $(2, 2), (-2, 2)$

② $y \leq -\frac{1}{2}x^2 + 8$; boundary curve $y = -\frac{1}{2}x^2 + 8$, parabola that opens downward with vertex $(0, 8)$ and points $(2, 6), (-2, 6), (4, 0), (-4, 0)$

③ $y \geq 0$

45a. $h = -4.9t^2 + 3.8t + 0.5$; $t = -\frac{b}{2a} = -\frac{3.8}{2(-4.9)} \approx 0.4$;

about 0.4 seconds 45b. Use $t = 2\left(-\frac{3.8}{2(-4.9)}\right) \approx 0.7755$:

$h \approx -4.9(0.7755)^2 + 3(0.7755) + 0.5 \approx 0.5$.

No; the height of the ball is about 0.5 m, so it will take more time to reach the ground. 46a. y -intercept: $(0, 2)$

46b. axis of symmetry: $x = -2.5$ 46c. $x = -\frac{b}{2a}; -2.5 = -\frac{b}{2(1)}$; $-5 = -b$; $b = 5$ 46d. $y = x^2 + 5x + 2$

46e. Answers may vary. Sample: Test $(-4, -2)$. $-2 \stackrel{?}{=} (-4)^2 + 5(-4) + 2$; $-2 \stackrel{?}{=} 16 - 20 + 2$; $-2 = -2 \checkmark$

46f. No; you would not be able to determine the b value using the vertex formula. 47. $y = x^2 - 2x - 1$;

$x = -\frac{b}{2a} = -\frac{-2}{2(1)} = 1$; $y = 1^2 - 2(1) - 1 = -2$;

vertex $(1, -2)$; A

48. F. $y = -x^2 - 2x$; $b = -2$ G. $y = -x^2 - 3x$; $b = -3$

H. $y = -x^2 + 2x$; $b = 2$ I. $y = -x^2 + 3x$; $b = 3$; the

answer is I. 49. $y = 0.5x^2 - 2x + 1$; $x = -\frac{b}{2a} = -\frac{-2}{2(0.5)} =$

2 ; $y = 0.5(2)^2 - 2(2) + 1 = -1$; vertex $(2, -1)$; B

50. [2] axis of symmetry: $x = \frac{-b}{2a} = \frac{-0.3}{2(-0.009)} \approx 16.7$;

maximum height: $y \approx -0.009(16.7)^2 + 0.3(16.7) + 4.5$;

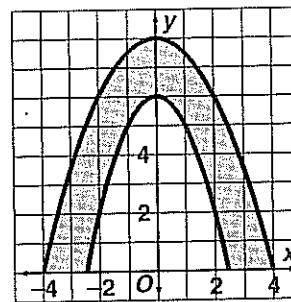
$y \approx 7$ ft [1] appropriate methods, but with a minor computational error 51. The parabola opens downward, so choose C, E, or F; vertex $(0, -2)$, so choose C or F; same shape as $y = -x^2$, so choose C. 52. The parabola opens upward, so choose A, B, or D; the graph is wider than $y = x^2$ and $y = \frac{1}{2}x^2$, so choose A. 53. The parabola opens downward, so choose C, E, or F; vertex $(0, -2)$, so choose C or F; the graph is wider than $y = -x^2$, so choose F. 54. The parabola opens upward, so choose A, B, or D; same shape as $y = x^2$ but shifted up 2 units, so choose D. 55. The parabola opens upward, so choose A, B, or D; the graph is wider than $y = x^2$, so choose B.

56. The parabola opens downward, so choose C, E, or F; vertex $(0, 2)$, so choose E. 57. $(c+4)(c-9) =$

$$c^2 - 9c + 4c - 36 = c^2 - 5c - 36$$

$$58. (2x-5)(x+6) = 2x^2 + 12x - 5x - 30 = 2x^2 + 7x - 30$$

$$59. (4t+1)(5t+3) = 20t^2 + 12t + 5t + 3 =$$



$$20t^2 + 17t + 3$$

$$60. (7n^2 - 2)(3n^2 - 8) =$$

$$21n^4 - 56n^2 - 6n^2 + 16 = 21n^4 - 62n^2 + 16$$

$$61. (a+5)(2a^2 - a + 4) =$$

$$2a^3 - a^2 + 4a + 10a^2 - 5a + 20 = 2a^3 + 9a^2 - a + 20$$

$$62. (3r^2 + 6r - 7)(2r - 1) =$$

$$6r^3 - 3r^2 + 12r^2 - 6r - 14r + 7 = 6r^3 + 9r^2 - 20r + 7$$

10-3 Finding and Estimating

Square Roots

pages 524-528

Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM*.

1. 121 2. 144 3. -144 4. 2.25 5. 0.36 6. $\frac{1}{4}$ 7. $\frac{4}{9}$ 8. $\frac{16}{25}$

Check Understanding 1a. $\sqrt{49} = 7$ 1b. $\pm\sqrt{36} = \pm 6$

1c. $-\sqrt{121} = -11$ 1d. $\sqrt{\frac{1}{25}} = \frac{1}{5}$ 2a. $\sqrt{8}$, irrational

2b. $\pm\sqrt{225} = \pm 15$, rational 2c. $-\sqrt{75}$, irrational

2d. $\sqrt{\frac{1}{4}} = \frac{1}{2}$, rational 3. $-\sqrt{121} < -\sqrt{105} < -\sqrt{100}$, so $-11 < -\sqrt{105} < -10$; between -11 and -10

4. $\sqrt{17.81} \approx 4.22$ 5. $2x = 140$, so $x = 70$; $d =$

$\sqrt{x^2 + (2x)^2} = \sqrt{70^2 + 140^2} = \sqrt{4900 + 19,600} =$

$\sqrt{24,500} \approx 156.5$; about 156.5 ft

Exercises 1. $\sqrt{169} = 13$ 2. $\sqrt{400} = 20$ 3. $\sqrt{\frac{1}{9}} = \frac{1}{3}$

4. $\sqrt{900} = 30$ 5. $\sqrt{0.25} = 0.5$ 6. $\sqrt{\frac{36}{49}} = \frac{6}{7}$

7. $-\sqrt{1.21} = -1.1$ 8. $\sqrt{1.96} = 1.4$ 9. $\sqrt{0.36} = 0.6$

10. $-\sqrt{144} = -12$ 11. $\sqrt{\frac{25}{16}} = \frac{5}{4}$ 12. $\pm\sqrt{0.01} = \pm 0.1$

13. $\sqrt{37}$, irrational 14. $-\sqrt{0.04} = -0.2$, rational

15. $\pm\sqrt{\frac{1}{5}}$, irrational 16. $-\sqrt{\frac{16}{121}} = -\frac{4}{11}$, rational

17. $\sqrt{25} < \sqrt{35} < \sqrt{36}$, so $5 < \sqrt{35} < 6$; between 5 and 6

18. $\sqrt{25} < \sqrt{27} < \sqrt{36}$, so $5 < \sqrt{27} < 6$; between 5 and 6

19. $-\sqrt{144} < -\sqrt{130} < -\sqrt{121}$, so $-12 < -\sqrt{130} < -11$; between -12 and -11

20. $\sqrt{169} < \sqrt{170} < \sqrt{196}$, so $13 < \sqrt{170} < 14$; between 13 and 14

21. $\sqrt{12} \approx 3.46$ 22. $-\sqrt{203} \approx$

-14.25 23. $\sqrt{11,550} \approx 107.47$ 24. $-\sqrt{150} \approx -12.25$

25. $e = \sqrt{\frac{r}{h}} = \sqrt{\frac{3}{3.5}} \approx 0.93$ 26. square roots of 400: ± 20

27. square root of 0: 0 28. square roots of 625: ± 25

29. square roots of $\frac{9}{4a}$: $\pm \frac{3}{2}$ 30. square roots of 1.69: ± 1.3

31. square roots of $\frac{1}{81}$: $\pm \frac{1}{9}$ 32. square roots of 729: ± 27

33. square roots of 2.25: ± 1.5 34. square roots of 256: ± 16

35. square roots of 0.01: ± 0.1 36. square roots of $\frac{64}{121}$: $\pm \frac{8}{11}$

37. square roots of 40,804: ± 202 38. 1

39a. $d = \sqrt{12,800h + h^2} = \sqrt{12,800(4200) + (4200)^2} =$

$\sqrt{71,400,000} \approx 8450$; 8450 km 39b. $d =$

$\sqrt{12,800h + h^2} = \sqrt{12,800(3600) + (3600)^2} =$

$\sqrt{59,040,000} \approx 7684$; 7684 km 40. $\sqrt{441} = 21$

41. $-\sqrt{\frac{4}{25}} = -\frac{2}{5}$ 42. $\sqrt{2} \approx 1.41$ 43. $\sqrt{1.6} \approx 1.26$

44. $-\sqrt{30} \approx -5.48$ 45. $-\sqrt{1089} = -33$

46. $-\sqrt{0.64} = -0.8$ 47. $\sqrt{41} \approx 6.40$ 48. $\sqrt{75} \approx 8.66$

49. Answers may vary. Sample: The first expression means the negative square root of 1, and the second expression means the positive square root of 1.

50. Answers may vary. Sample: 3 and 4 (since

$$3^2 + 4^2 = 9 + 16 = 25, \text{ a perfect square})$$

51. $\sqrt{16} = 4$
 52a. $t = \sqrt{\frac{d}{16}} = \sqrt{\frac{400}{16}} = \sqrt{25} = 5$ s 52b. $t = \sqrt{\frac{d}{16}} = \sqrt{\frac{1600}{16}} = \sqrt{100} = 10$; 10 s 52c. No; the object takes only twice as long to fall. 53. False; zero has only one square root. 54. False; $\sqrt{1} = 1$. 55. True
 56. True 57. False; answers may vary. Sample:
 $\sqrt{4} + \sqrt{9} \neq \sqrt{4+9}$. 58. False; answers may vary.
 Sample: $\sqrt{12}$ and $\sqrt{3}$ are irrational, but $\sqrt{36}$ is rational.

59a. Area = $2(2) = 4$ units² 59b. $\frac{1}{2}$ units²

59c. $4\left(\frac{1}{2}\text{ units}^2\right) = 2$ units² 59d. $\sqrt{2}$ units 60. $\sqrt{1.69} =$

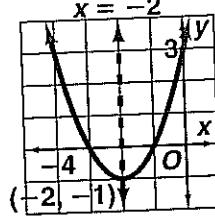
1.3 61. $\sqrt{4^2 + 3^2 + 11} = \sqrt{36} = 6$ 62. $\sqrt{\frac{4}{81}} = \frac{2}{9}$

63. $\sqrt{80} \approx 9$ 64. $\ell = \sqrt{\frac{1}{6}} = \sqrt{\frac{726}{6}} = \sqrt{121} = 11$

65. $\sqrt{100} \cdot \sqrt{256} - \sqrt{16} \cdot \sqrt{64} = 10(16) - 4(8) =$

$$160 - 32 = 128$$

66. $y = x^2 + 4x + 3$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{4}{2(1)} = -2$, $x = -2$; y-coordinate of vertex: $y = (-2)^2 + 4(-2) + 3 = -1$; vertex $(-2, -1)$; points $(0, 3)$, $(-4, 3)$

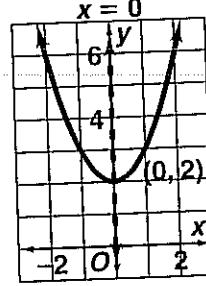


67. $y = x^2 + 2$; axis of symmetry:

$$x = -\frac{b}{2a} = -\frac{0}{2(1)} = 0, x = 0;$$

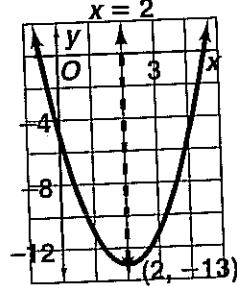
y-coordinate of vertex:

$$y = 0^2 + 2 = 2; \text{ vertex } (0, 2); \text{ points } (2, 6), (-2, 6)$$



68. $y = 2x^2 - 8x - 5$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-8}{2(2)} = 2$,

$$x = 2, y = 2; \text{ y-coordinate of vertex: } y = 2(2)^2 - 8(2) - 5 = -13; \text{ vertex } (2, -13); \text{ points } (0, -5), (4, -5)$$

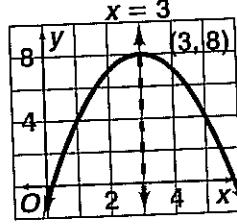


69. $y = -x^2 + 6x - 1$; axis of symmetry:

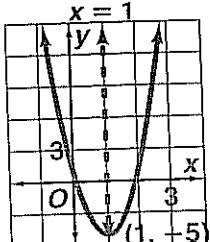
$$x = -\frac{b}{2a} = -\frac{6}{2(-1)} = 3$$

$x = 3$; y-coordinate of vertex:

$$y = -3^2 + 6(3) - 1 = 8; \text{ vertex } (3, 8); \text{ points } (1, 4), (5, 4)$$



70. $y = 6x^2 - 12x + 1$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-12}{2(6)} = 1$, $x = 1$; y-coordinate of vertex:
 $y = 6(1)^2 - 12(1) + 1 = -5$; vertex $(1, -5)$; points $(0, 1), (2, 1)$



71. $y = -3x^2 + 18x$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{18}{2(-3)} = 3$, $x = 3$; y-coordinate of vertex:
 $y = -3(3)^2 + 18(3) = 27$; vertex $(3, 27)$; points $(0, 0), (6, 0), (1, 15), (5, 15)$

72. $(d+9)(d-9) = d^2 - 9d + 9d - 81 = d^2 - 81$

73. $(3t-5)(3t+5) =$

$$9t^2 + 15t - 15t - 25 = 9t^2 - 25 \quad 74. 85 \cdot 95 = (90-5)(90+5) = 90^2 - 5^2 = 8100 - 25 = 8075$$

75. $(x+13)^2 = (x+13)(x+13) = x^2 + 13x + 13x + 169 = x^2 + 26x + 169$

76. $(4y-7)^2 = (4y-7)(4y-7) = 16y^2 - 28y + 49 = 16y^2 - 56y + 49 \quad 77. 101^2 = (100+1)^2 = 100^2 + 2(100 \cdot 1) + 1^2 = 10,000 + 200 + 1 = 10,201 \quad 78. 902^2 = (900+2)^2 = 900^2 + 2(900 \cdot 2) + 2^2 = 810,000 + 3600 + 4 = 813,604 \quad 79. (6k-7)(6k+7) = 36k^2 + 42k - 42k - 49 = 36k^2 - 49 \quad 80. (12b-7)^2 = (12b-7)(12b-7) = 144b^2 - 84b - 84b + 49 = 144b^2 - 168b + 49 \quad 81. x^{-2}y^{-1}z^2 = \frac{z^2}{x^2y} = \frac{z^2}{3^2(-2)} = \frac{6^2}{144} = \frac{1}{12}$

$$\frac{36}{-18} = -2 \quad 82. \frac{y^{-2}}{x^{-3}z^2} = \frac{x^3}{y^2z^2} = \frac{3^3}{(-2)^2 \cdot 6^2} = \frac{27}{144} = \frac{3}{16}$$

$$\frac{x^0y^{-3}}{z^{-1}} = \frac{z}{y^3} = \frac{6}{(-2)^3} = \frac{6}{-8} = -\frac{3}{4}$$

$$\frac{x^2y^{-1}}{z^{-3}} = \frac{x^2z^3}{y} = \frac{3^2 \cdot 6^3}{-2} = \frac{1944}{-2} = -972$$

$$85. x^{-1}y^{-2}z^0 = \frac{1}{xy^2} = \frac{1}{3(-2)^2} = \frac{1}{12}$$

$$86. x^2y^{-4}z^2 = \frac{x^2z^2}{y^4} = \frac{3^2 \cdot 6^2}{(-2)^4} = \frac{324}{16} = \frac{81}{4}$$

10-4 Solving Quadratic Equations

pages 529–534

Check Skills You'll Need For complete solutions see Daily Skills Check and Lesson Quiz Transparencies or Presentation Pro CD-ROM.

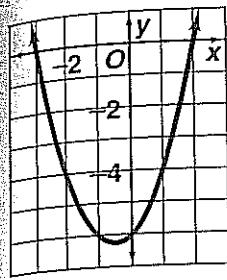
1. 6 2. -9 3. ± 11 4. 1.2 5. 0.5 6. ± 1.1 7. $\frac{1}{2}$ 8. $\pm \frac{1}{3}$

9. $\frac{7}{10}$

Investigation 1a. $1\frac{1}{2}$. 1b. -4 and 1 2a. $2x - 3 = 0$:

2x = 3; $x = \frac{3}{2} = 1\frac{1}{2}$ 2b. yes 3. Check $x = -4$:

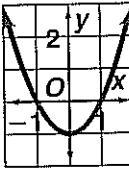
$$(-4)^2 + 3(-4) - 4 = 16 - 12 - 4 = 0, \text{ yes; check } x = 1: 1^2 + 3(1) - 4 = 1 + 3 - 4 = 0, \text{ yes. 4a. } y = x^2 + x - 6; \text{ axis of symmetry: } x = -\frac{b}{2a} = -\frac{1}{2(1)} = -\frac{1}{2}, \text{ y-coordinate of vertex: } y = \left(-\frac{1}{2}\right)^2 + \left(-\frac{1}{2}\right) - 6 = -6\frac{1}{4}; \text{ vertex } \left(-\frac{1}{2}, -6\frac{1}{4}\right); \text{ points } (1, -4), (2, 0)$$



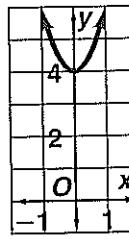
- 4b.** -3 and 2 **4c.** Check $x = -3$:
 $(-3)^2 + (-3) - 6 = 9 - 3 - 6 = 0$; yes; check $x = 2$: $2^2 + 2 - 6 = 4 + 2 - 6 = 0$; yes.

Check Understanding

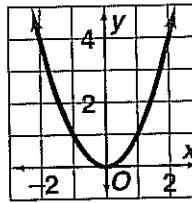
- 1a.** $x^2 - 1 = 0$;
graph $y = x^2 - 1$;
 $x = \pm 1$



- 1b.** $2x^2 + 4 = 0$;
graph $y = 2x^2 + 4$;
no solution

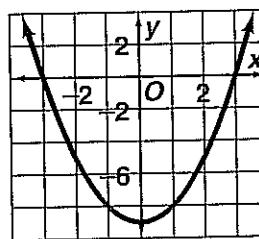


- 1c.** $x^2 - 16 = -16$;
 $x^2 = 0$;
graph $y = x^2$;
 $x = 0$

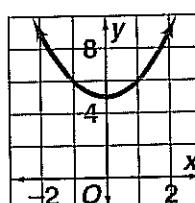


- 2a.** $t^2 - 25 = 0$; $t^2 = 25$; $t = \pm\sqrt{25}$; $t = \pm 5$
2b. $3n^2 + 12 = 12$; $3n^2 = 0$; $n^2 = 0$; $n = 0$ **2c.** $2g^2 + 32 = 0$; $2g^2 = -32$; $g^2 = -16$; no solution **3.** $V = \pi r^2 h$;
 $1800 = \pi r^2 (3)$; $r^2 = \frac{1800}{3\pi}$; $r = \sqrt{\frac{1800}{3\pi}} \approx 13.8$; about 14 ft

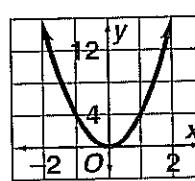
- Exercises** **1.** $x^2 - 9 = 0$;
graph $y = x^2 - 9$;
 $x = \pm 3$



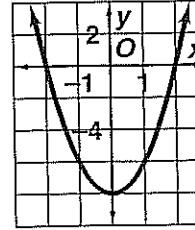
- 2.** $x^2 + 5 = 0$;
graph $y = x^2 + 5$;
no solution



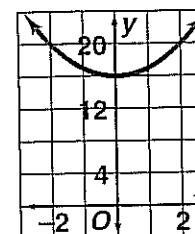
- 3.** $4x^2 = 0$;
graph $y = 4x^2$;
 $x = 0$



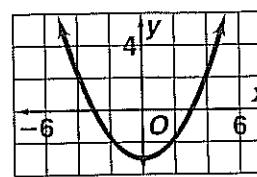
- 4.** $2x^2 - 8 = 0$;
graph $y = 2x^2 - 8$;
 $x = \pm 2$



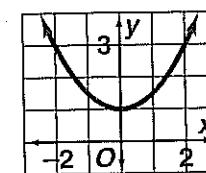
- 5.** $x^2 + 16 = 0$;
graph $y = x^2 + 16$;
no solution



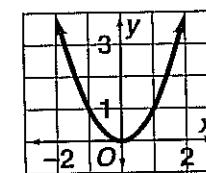
- 6.** $\frac{1}{3}x^2 - 3 = 0$;
graph $y = \frac{1}{3}x^2 - 3$;
 $x = \pm 3$



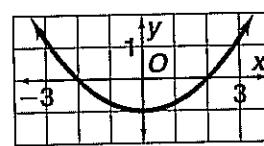
- 7.** $\frac{1}{2}x^2 + 1 = 0$;
graph $y = \frac{1}{2}x^2 + 1$;
no solution



- 8.** $x^2 + 7 = 7$;
 $x^2 = 0$;
graph $y = x^2$;
 $x = 0$



- 9.** $\frac{1}{4}x^2 - 1 = 0$;
graph $y = \frac{1}{4}x^2 - 1$;
 $x = \pm 2$



- 10.** $k^2 = 49$; $k = \pm\sqrt{49}$; $k = \pm 7$ **11.** $b^2 = 441$; $b = \pm\sqrt{441}$; $b = \pm 21$ **12.** $m^2 - 225 = 0$; $m^2 = 225$; $m = \pm\sqrt{225}$; $m = \pm 15$ **13.** $c^2 + 25 = 25$; $c^2 = 0$; $c = 0$

- 14.** $x^2 - 9 = -16$; $x^2 = -7$; no solution **15.** $4r^2 = 25$;
 $r^2 = \frac{25}{4}$; $r = \pm\sqrt{\frac{25}{4}}$; $r = \pm\frac{5}{2}$ **16.** $64p^2 = 4$; $p^2 = \frac{4}{64} = \frac{1}{16}$; $p = \pm\sqrt{\frac{1}{16}}$; $p = \pm\frac{1}{4}$ **17.** $6w^2 - 24 = 0$; $6w^2 = 24$; $w^2 = 4$; $w = \pm\sqrt{4}$; $w = \pm 2$ **18.** $27 - y^2 = 0$; $27 = y^2$; $y = \pm\sqrt{27}$ **19.** $x^2 = 256$; $x = \sqrt{256} = 16$; 16 m

- 20.** $x^2 = 90$; $x = \sqrt{90} \approx 9.5$; about 9.5 ft **21.** $\pi r^2 = 80$;
 $r^2 = \frac{80}{\pi}$; $r = \sqrt{\frac{80}{\pi}} \approx 5.0$; about 5.0 cm **22a.** $4\pi r^2 = 450$;
 $r^2 = \frac{450}{4\pi}$; $r = \sqrt{\frac{450}{4\pi}} \approx 6.0$; about 6.0 in.

- 22b.** The length of a radius cannot be negative. **23.** $y^2 = -36$; none
24. $a^2 - 12 = 6$; $a^2 = 18$; two **25.** $n^2 - 15 = -15$; $n^2 = 0$; one
26. $x^2 = 0.75(12^2) = 108$; $x = \sqrt{108} \approx 10.4$; 10.4 in.
by 10.4 in. **27a.** $\pi r^2 = 400$; $r^2 = \frac{400}{\pi}$; $r = \sqrt{\frac{400}{\pi}} \approx 11.3$; 11.3 ft **27b.** $\pi r^2 = 800$; $r^2 = \frac{800}{\pi}$; $r = \sqrt{\frac{800}{\pi}} \approx 16.0$; 16.0 ft

27c. $16.0 \div 11.3 \approx 1.4 \neq 2$; no, the radius increases by about 1.4 times. **28.** $1.2q^2 - 7 = -34$; $1.2q^2 = -27$; $q^2 = -\frac{27}{1.2}$; no solution **29.** $49t^2 - 16 = -7$; $49t^2 = 9$; $t^2 = \frac{9}{49}$; $t = \pm\sqrt{\frac{9}{49}} = \pm\frac{3}{7}$ **30.** $3d^2 - \frac{1}{12} = 0$; $3d^2 = \frac{1}{12}$; $d^2 = \frac{1}{36}$; $d = \pm\sqrt{\frac{1}{36}} = \pm\frac{1}{6}$ **31.** $\frac{1}{2}x^2 - 4 = 0$; $\frac{1}{2}x^2 = 4$; $x^2 = 8$; $x = \pm\sqrt{8} \approx \pm2.8$ **32.** $7h^2 + 0.12 = 1.24$; $7h^2 = 1.12$; $h^2 = \frac{1.12}{7} = 0.16$; $h = \pm\sqrt{0.16} = \pm0.4$ **33.** $-\frac{1}{4}x^2 + 3 = 0$; $-\frac{1}{4}x^2 = -3$; $x^2 = 12$; $x = \pm\sqrt{12} \approx \pm3.5$ **34.** $d = \frac{1}{2}at^2$; $12 = \frac{1}{2} \cdot 2t^2$; $t^2 = 12$; $t = \sqrt{12} \approx 3.5$ s **35.** $x^2 - c = 0$; $x^2 = c$; $11^2 = c$ and $(-11)^2 = c$, so $c = 121$ **36a.** $x^2 = n$ has two solutions when $n > 0$. **36b.** $x^2 = n$ has exactly one solution when $n = 0$. **36c.** $x^2 = n$ has no solution when $n < 0$. **37.** Answers may vary. Sample: Michael subtracted 25 from the left side of the equation but added 25 to the right side.

38a. To solve $x^2 - 4 = 0$, graph $y = x^2 - 4$; to solve $2x^2 - 8 = 0$, graph $y = 2x^2 - 8$.

Both equations have the solutions 2 and -2.

38b. The first equation multiplied by 2 on both sides equals the second equation. **39a.** area of square: $(2r)^2$, or $4r^2$; area of circle: πr^2 **39b.** $4r^2 - \pi r^2 = 80$

39c. $r^2(4 - \pi) = 80$; $r^2 = \frac{80}{4 - \pi}$; $r = \sqrt{\frac{80}{4 - \pi}} \approx 9.7$; $2r = 2\sqrt{\frac{80}{4 - \pi}} \approx 19.3$; radius of circle ≈ 9.7 in., side of square ≈ 19.3 in. **40.** Answers may vary. Samples are given. **40a.** $5x^2 + 10 = 0$; $5x^2 = -10$; $x^2 = -2$; no solution **40b.** $2x^2 + 0 = 0$; $2x^2 = 0$; $x^2 = 0$; $x = 0$

40c. $-20x^2 + 80 = 0$; $-20x^2 = -80$; $x^2 = 4$; $x = \pm\sqrt{4} = \pm2$ **41.** $A = \frac{1}{2}bh$; $20 = \frac{1}{2}h^2$; $h^2 = 40$; $h = \sqrt{40} \approx 6.3$; 6.3 ft **42.** $A = \frac{1}{2}bh$; $120 = \frac{1}{2} \cdot 2h^2$; $h^2 = 120$; $h = \sqrt{120} \approx 11.0$; 11.0 cm **43a.** $\ell = \frac{2.45t^2}{\pi^2} = \frac{2.45 \cdot 1^2}{\pi^2} \approx 0.2$; 0.2 m **43b.** $1.6 = \frac{2.45t^2}{\pi^2}$; $t^2 = \frac{1.6\pi^2}{2.45}$; $t = \sqrt{\frac{1.6\pi^2}{2.45}} \approx 2.5$; 2.5 s **43c.** $2.2 = \frac{2.45t^2}{\pi^2}$; $t^2 = \frac{2.2\pi^2}{2.45}$; $t = \sqrt{\frac{2.2\pi^2}{2.45}} \approx 3.0$; 3.0 s

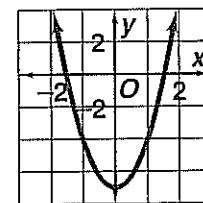
43d. You would shorten the pendulum, because as ℓ decreases, t decreases. **44a.** $(x + 7)^2 = 0$; $x + 7 = 0$; $x = -7$ **44b.** $y = (x + 7)^2$; vertex $(-7, 0)$ **44c.** Answers may vary. Sample: $h = 5$; solution to $y = (x + 5)^2$ is -5; vertex of $y = (x + 5)^2$ is $(-5, 0)$. **44d.** Vertex at $(4, 0)$, because the vertex is at $(-h, 0)$. **45.** $A = \frac{1}{2}h(b_1 + b_2)$; $1960 = \frac{1}{2}y(y + 4y)$; $1960 = \frac{1}{2}y(5y)$; $1960 = \frac{5}{2}y^2$; $y^2 = \frac{2}{5}(1960)$; $y^2 = 784$; $y = \sqrt{784} = 28$; 28 cm **46.** $3x^2 - 48 = 0$; $3x^2 = 48$; $x^2 = 16$; $x = \pm\sqrt{16} = \pm4$; B

47. F. $5x^2 + 1 = 10$, $5x^2 = 9$, $x^2 = \frac{9}{5}$, two solutions **G.** $5x^2 + 5 = 10$, $5x^2 = 5$, $x^2 = 1$, two solutions **H.** $5x^2 + 9 = 10$, $5x^2 = 1$, $x^2 = \frac{1}{5}$, two solutions

I. $5x^2 + 12 = 10$, $5x^2 = -2$, $x^2 = -\frac{2}{5}$, no solution; the answer is I. **48.** The graph is shifted up 4 units from the origin, so the answer is $-0.25x^2 + 4 = 0$, B.

49. [2]

x	$y = 3x^2 - 7$	(x, y)
-2	$3(-2)^2 - 7 = 5$	$(-2, 5)$
-1	$3(-1)^2 - 7 = -4$	$(-1, -4)$
0	$3(0)^2 - 7 = -7$	$(0, -7)$
1	$3(1)^2 - 7 = -4$	$(1, -4)$
2	$3(2)^2 - 7 = 5$	$(2, 5)$



x -intercepts $\approx 1.5, \approx -1.5$

[1] minor error in table OR incorrect graph

50. [4] **50a.** $96 = 6s^2$; $s^2 = 16$; $s = 4$ ft.

50b. $6(8)^2 = 6 \cdot 64 = 384$, so the surface area is 384 ft^2 . And $96 \cdot 4 = 384$, so the surface area is quadrupled. [3] appropriate methods, but with one computational error [2] part (a) done correctly [1] no work shown

51. $\sqrt{9} = 3$ **52.** $-\sqrt{169} = -13$ **53.** $\sqrt{1600} = 40$

54. $\sqrt{225} = 15$ **55.** $\sqrt{0.04} = 0.2$ **56.** $-\sqrt{2.56} = -1.6$

57. $\sqrt{\frac{25}{64}} = \frac{5}{8}$ **58.** $\sqrt{\frac{49}{81}} = \frac{7}{9}$ **59.** $x^2 + 5x + 4 = (x + 4)(x + 1)$ **60.** $y^2 - 15y + 26 = (y - 13)(y - 2)$

61. $a^2 + 3a - 10 = (a + 5)(a - 2)$ **62.** $z^2 - 6z - 72 = (z - 12)(z + 6)$ **63.** $c^2 - 14cd + 24d^2 = (c - 12d)(c - 2d)$ **64.** $t^2 + tu - 2u^2 = (t + 2u)(t - u)$

65. $3,613,500 = 3.6135 \times 10^6$ **66.** $0.0000348 = 3.48 \times 10^{-5}$ **67.** $-8.12 = -8.12 \times 10^0$ **68.** $3.1 \times 10^4 = 31,000$ **69.** $7.01 \times 10^5 = 701,000$ **70.** $6.2 \times 10^{-4} = 0.00062$

CHECKPOINT QUIZ 1

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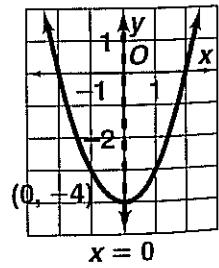
1. $y = x^2 - 4$, or $y = x^2 + 0x - 4$;

axis of symmetry: $x = -\frac{b}{2a} = -\frac{0}{2(1)} = 0$, $x = 0$; y -coordinate

of vertex: $y = 0^2 - 4 = -4$;

vertex $(0, -4)$;

points $(2, 0), (-2, 0)$



2. $y = 8x^2 - 2x$; axis of

symmetry: $x = -\frac{b}{2a} =$

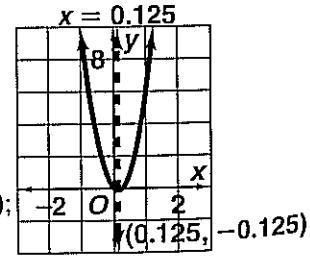
$-\frac{-2}{2(8)} = \frac{1}{8} = 0.125$, $x = 0.125$;

y -coordinate of vertex:

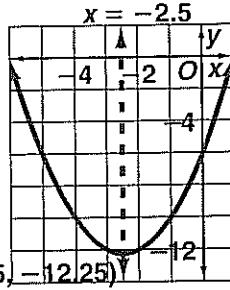
$y = 8(0.125)^2 - 2(0.125) =$

-0.125 ; vertex $(0.125, -0.125)$;

points $(0, 0), (1, 6), (-1, 10)$



3. $f(x) = x^2 + 5x - 6$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{5}{2(1)} = -2.5$, $x = -2.5$; y -coordinate of vertex: $y = (-2.5)^2 + 5(-2.5) - 6 = -12.25$; vertex $(-2.5, -12.25)$; points $(0, -6), (1, 0)$



4a. $h = -16t^2 + 24t + 6$; $(-2.5, -12.25)$
 $t = -\frac{b}{2a} = -\frac{24}{2(-16)} = 0.75$;

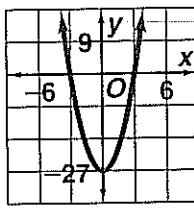
0.75 s 4b. $h = -16(0.75)^2 + 24(0.75) + 6 = 15$; 15 ft

5. $\sqrt{100} = 10$ 6. $\pm\sqrt{0.36} = \pm 0.6$ 7. $-\sqrt{4} = -2$

8. $t^2 - 64 = 0$; $t^2 = 64$; $t = \pm\sqrt{64} = \pm 8$

9. $6m^2 - 150 = 0$; $6m^2 = 150$; $m^2 = 25$; $m = \pm\sqrt{25} = \pm 5$

10. $3x^2 - 27 = 0$;
graph $y = 3x^2 - 27$;
 $x = \pm 3$



TECHNOLOGY

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1. 10.78, 13.22 2. $-2, 8$ 3. $-2, 1.5$ 4. $-24, 37, 0.37$

5. 0.28, 17.72 6. $-4.88, 36.88$ 7. $-12, 6$ 8a. $A = \ell w$;

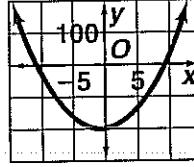
$200 = x(2x + 3)$; $2x^2 + 3x - 200 = 0$

8b. graph $y = 2x^2 + 3x - 200$

8c. $x \approx 9.28$, $2x + 3 \approx$

$2(9.28) + 3 = 21.56$;

9.28 cm by 21.56 cm



10-5 Factoring to Solve Quadratic Equations

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Check Skills You'll Need For complete solutions see *Daily Skills Check and Lesson Quiz Transparencies* or *Presentation Pro CD-ROM*.

1. -1 2. 104 3. $-2\frac{5}{7}$ 4. $(2c + 1)(c + 14)$

5. $(3p + 2)(p + 10)$ 6. $(4x + 3)(x - 6)$

Check Understanding 1a. $(x + 7)(x - 4) = 0$; $x + 7 = 0$ or $x - 4 = 0$; $x = -7$ or $x = 4$ 1b. $(3y - 5)(y - 2) = 0$; $3y - 5 = 0$ or $y - 2 = 0$; $3y = 5$ or $y = 2$; $y = \frac{5}{3}$ or $y = 2$ 1c. $(6k + 9)(4k - 11) = 0$; $6k + 9 = 0$ or $4k - 11 = 0$; $6k = -9$ or $4k = 11$; $k = -\frac{9}{6} = -\frac{3}{2}$ or $k = \frac{11}{4}$ 2. $x^2 + x - 12 = 0$; $(x + 4)(x - 3) = 0$; $x + 4 = 0$ or $x - 3 = 0$; $x = -4$ or $x = 3$ 3. $x^2 - 12x = -36$;

$x^2 - 12x + 36 = 0$; $(x - 6)(x - 6) = 0$; $x - 6 = 0$ or $x - 6 = 0$; $x = 6$ 4. width of material = $x + 2 + 2 = x + 4$; length of material = $x + 1 + 2 + 2 = x + 5$; $(x + 4)(x + 5) = 182$; $x^2 + 9x + 20 = 182$; $x^2 + 9x - 162 = 0$; $(x + 18)(x - 9) = 0$; $x + 18 = 0$ or $x - 9 = 0$; $x = -18$ or $x = 9$, use $x = 9$; 9 in. \times 10 in. \times 2 in.

Exercises 1. $(x - 3)(x - 7) = 0$; $x - 3 = 0$ or $x - 7 = 0$;

$x = 3$ or $x = 7$ 2. $(x + 4)(2x - 9) = 0$; $x + 4 = 0$ or $2x - 9 = 0$; $x = -4$ or $2x = 9$; $x = -4$ or $x = 4.5$

3. $t(t + 1) = 0$; $t = 0$ or $t + 1 = 0$; $t = 0$ or $t = -1$

4. $-3n(2n - 5) = 0$; $-3n = 0$ or $2n - 5 = 0$; $n = 0$ or $2n = 5$; $n = 0$ or $n = 2.5$ 5. $(7x + 2)(5x + 4) = 0$;

$7x + 2 = 0$ or $5x + 4 = 0$; $7x = -2$ or $5x = -4$; $x = -\frac{2}{7}$

or $x = -\frac{4}{5}$ 6. $(4a - 7)(3a + 8) = 0$; $4a - 7 = 0$ or

$3a + 8 = 0$; $4a = 7$ or $3a = -8$; $a = \frac{7}{4}$ or $a = -\frac{8}{3}$

7. $b^2 + 3b - 4 = 0$; $(b - 1)(b + 4) = 0$; $b - 1 = 0$ or $b + 4 = 0$; $b = 1$ or $b = -4$ 8. $m^2 - 5m - 14 = 0$;

$(m + 2)(m - 7) = 0$; $m + 2 = 0$ or $m - 7 = 0$; $m = -2$ or $m = 7$ 9. $w^2 - 8w = 0$; $w(w - 8) = 0$; $w = 0$ or $w - 8 = 0$; $w = 0$ or $w = 8$ 10. $x^2 - 16x + 55 = 0$;

$(x - 5)(x - 11) = 0$; $x - 5 = 0$ or $x - 11 = 0$; $x = 5$ or $x = 11$ 11. $k^2 - 3k - 10 = 0$; $(k + 2)(k - 5) = 0$;

$k + 2 = 0$ or $k - 5 = 0$; $k = -2$ or $k = 5$

12. $n^2 + n - 12 = 0$; $(n - 3)(n + 4) = 0$; $n - 3 = 0$ or $n + 4 = 0$; $n = 3$ or $n = -4$ 13. $x^2 + 8x = -15$;

$x^2 + 8x + 15 = 0$; $(x + 3)(x + 5) = 0$; $x + 3 = 0$ or $x + 5 = 0$; $x = -3$ or $x = -5$ 14. $t^2 - 3t = 28$;

$t^2 - 3t - 28 = 0$; $(t + 4)(t - 7) = 0$; $t + 4 = 0$ or $t - 7 = 0$; $t = -4$ or $t = 7$ 15. $n^2 = 6n$; $n^2 - 6n = 0$;

$n(n - 6) = 0$; $n = 0$ or $n - 6 = 0$; $n = 0$ or $n = 6$

16. $2c^2 - 7c = -5$; $2c^2 - 7c + 5 = 0$; $(2c - 5)(c - 1) = 0$;

$2c - 5 = 0$ or $c - 1 = 0$; $2c = 5$ or $c = 1$; $c = 2.5$ or $c = 1$ 17. $3q^2 + 16q = -5$; $3q^2 + 16q + 5 = 0$;

$(3q + 1)(q + 5) = 0$; $3q + 1 = 0$ or $q + 5 = 0$; $3q = -1$

or $q = -5$; $q = -\frac{1}{3}$ or $q = -5$ 18. $4y^2 = 25$;

$4y^2 - 25 = 0$; $(2y - 5)(2y + 5) = 0$; $2y - 5 = 0$ or

$2y + 5 = 0$; $2y = 5$ or $2y = -5$; $y = 2.5$ or $y = -2.5$

19. $5q^2 + 18q = 8$; $5q^2 + 18q - 8 = 0$; $(5q - 2)(q + 4) = 0$;

$5q - 2 = 0$ or $q + 4 = 0$; $5q = 2$ or $q = -4$; $q = \frac{2}{5}$ or

$q = -4$ 20. $2z^2 - 10z = -12$; $2z^2 - 10z + 12 = 0$;

$(2z - 6)(z - 2) = 0$; $2z - 6 = 0$ or $z - 2 = 0$; $2z = 6$ or $z = 2$; $z = 3$ or $z = 2$ 21. $12 = 2x^2 + 5x$; $2x^2 + 5x - 12 = 0$;

$(2x - 3)(x + 4) = 0$; $2x - 3 = 0$ or $x + 4 = 0$; $2x = 3$ or $x = -4$; $x = \frac{3}{2}$ or $x = -4$ 22. $(x + 3)^2 = 64$;

$x^2 + 6x + 9 = 64$; $x^2 + 6x - 55 = 0$; $(x - 5)(x + 11) = 0$;

$x - 5 = 0$ or $x + 11 = 0$; $x = 5$ or $x = -11$, use $x = 5$; 5 cm 23. $V = \ell wh$; $280 = 4(n + 2)(n + 5)$; $70 = (n + 2)(n + 5)$; $n^2 + 7n + 10 = 70$; $n^2 + 7n - 60 = 0$;

$(n + 12)(n - 5) = 0$; $n + 12 = 0$ or $n - 5 = 0$; $n = -12$ or $n = 5$, use $n = 5$ 24. $w(2w + 3) = 90$;

$2w^2 + 3w - 90 = 0$; $(2w + 15)(w - 6) = 0$; $2w + 15 = 0$ or $w - 6 = 0$; $2w = -15$ or $w = 6$; $w = -7.5$ or $w = 6$, use $w = 6$; $2w + 3 = 2(6) + 3 = 15$; 6 ft \times 15 ft

25. $A = \frac{1}{2}bh$; $110 = \frac{1}{2}x(2x + 2)$; $110 = x^2 + x$;

$x^2 + x - 110 = 0$; $(x - 10)(x + 11) = 0$; $x - 10 = 0$ or $x + 11 = 0$; $x = 10$ or $x = -11$, use $x = 10$; $2x + 2 = 2(10) + 2 = 22$; the base is 10 ft, and the height is 22 ft.

26. $x(x + 1) = 10x - 14$; $x^2 + x = 10x - 14$;

$x^2 - 9x + 14 = 0$; $(x - 2)(x - 7) = 0$; $x - 2 = 0$ or $x - 7 = 0$; $x = 2$ or $x = 7$; the numbers are 2 and 3, or 7 and 8. 27. $2q^2 + 22q = -60$; $2q^2 + 22q + 60 = 0$;

$q^2 + 11q + 30 = 0$; $(q + 6)(q + 5) = 0$; $q + 6 = 0$ or

$$q + 5 = 0; q = -6 \text{ or } q = -5$$

$$28. 4 = -5n + 6n^2; 6n^2 - 5n - 4 = 0; (3n - 4)(2n + 1) = 0; 3n - 4 = 0 \text{ or}$$

$$2n + 1 = 0; 3n = 4 \text{ or } 2n = -1; n = \frac{4}{3} \text{ or } n = -\frac{1}{2}$$

$$29. 6y^2 + 12y + 13 = 2y^2 + 4; 4y^2 + 12y + 9 = 0;$$

$$(2y + 3)(2y + 3) = 0; 2y + 3 = 0; 2y = -3; y = -\frac{3}{2}$$

$$30. 3a^2 + 4a = 2a^2 - 2a - 9; a^2 + 6a + 9 = 0;$$

$$(a + 3)(a + 3) = 0; a + 3 = 0; a = -3$$

$$31. 3t^2 + 8t = t^2 - 3t - 12; 2t^2 + 11t + 12 = 0;$$

$$(2t + 3)(t + 4) = 0; 2t + 3 = 0 \text{ or } t + 4 = 0; 2t = -3 \text{ or}$$

$$t = -4; t = -1.5 \text{ or } t = -4$$

$$32. 4x^2 + 20 = 10x + 3x^2 - 4; x^2 - 10x + 24 = 0; (x - 4)(x - 6) = 0;$$

$$x - 4 = 0 \text{ or } x - 6 = 0; x = 4 \text{ or } x = 6$$

$$33. 2k^2 - 3 + 12k = k + 60; 2k^2 + 11k - 63 = 0;$$

$$(2k - 7)(k + 9) = 0; 2k - 7 = 0 \text{ or } k + 9 = 0;$$

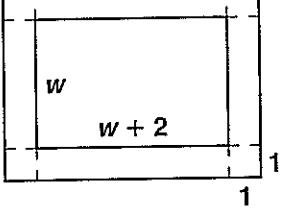
$$2k = 7 \text{ or } k = -9; k = \frac{7}{2} \text{ or } k = -9$$

$$34. 15y^2 + 45y - 9 = 4y - 5y^2; 20y^2 + 41y - 9 = 0;$$

$$(5y - 1)(4y + 9) = 0; 5y - 1 = 0 \text{ or } 4y + 9 = 0;$$

$$5y = 1 \text{ or } 4y = -9; y = \frac{1}{5} \text{ or } y = -\frac{9}{4}$$

35.



$$\text{width of material} = w + 1 + 1 = w + 2;$$

$$\text{length of material} = w + 2 + 1 + 1 = w + 4;$$

$$(w + 2)(w + 4) = 80; w^2 + 6w + 8 = 80;$$

$$w^2 + 6w - 72 = 0; (w - 6)(w + 12) = 0; w - 6 = 0 \text{ or}$$

$$w + 12 = 0; w = 6 \text{ or } w = -12, \text{ use } w = 6; w + 2 = 8,$$

$$w + 4 = 10; 8 \text{ in.} \times 10 \text{ in.}$$

$$36a. -16t^2 + 29t + 6 = 0; 16t^2 - 29t - 6 = 0;$$

$$(16t + 3)(t - 2) = 0; 16t + 3 = 0 \text{ or } t - 2 = 0; 16t = -3$$

$$\text{or } t = 2; t = -\frac{3}{16} \text{ or } t = 2, \text{ use } t = 2; 2 \text{ s}$$

36b. Vertex of graph is about (0.9, 19.14); about 19 ft. 37. Answers may vary. Sample: To solve a quadratic equation, write the equation in standard form, factor the quadratic expression, use the Zero-Product Property, and solve for the variable. $x^2 + 8x = -15; x^2 + 8x + 15 = 0$.

$$(x + 3)(x + 5) = 0; x + 3 = 0 \text{ or } x + 5 = 0; x = -3 \text{ or}$$

$$x = -5$$

38. Answers may vary. Sample: $A = 56 = 8 \cdot 7$, so $x = 6$, $a = 2$, and $b = 1$; $A = 56 = 4 \cdot 14$, so $x = 3$,

$a = 1$, and $b = 11$. 39. Answers may vary. Sample:

$$x^2 - 2x - 8 = 0; (x - 4)(x + 2) = 0; x - 4 = 0 \text{ or}$$

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

$$40a. \text{ (1)} x^2 = x; x^2 - x = 0; \text{ (2)} x(x - 1) = 0; x = 0 \text{ or } x - 1 = 0; x = 0 \text{ or } x = 1$$

$$x^2 - x = 0; x(x + 1) = 0; x = 0 \text{ or } x + 1 = 0;$$

$$x = 0 \text{ or } x = -1$$

$$40b. 0$$

$$41. x^3 - 10x^2 + 24x = 0;$$

$$x(x^2 - 10x + 24) = 0; x(x - 4)(x - 6) = 0; x = 0 \text{ or}$$

$$x - 4 = 0 \text{ or } x - 6 = 0; x = 0 \text{ or } x = 4 \text{ or } x = 6$$

$$42. x^3 - 5x^2 + 4x = 0; x(x^2 - 5x + 4) = 0;$$

$$x(x - 1)(x - 4) = 0; x = 0 \text{ or } x - 1 = 0 \text{ or } x - 4 = 0;$$

$$x = 0 \text{ or } x = 1 \text{ or } x = 4$$

$$43. 3x^3 - 9x^2 = 0;$$

$$3x^2(x - 3) = 0; 3x^2 = 0 \text{ or } x - 3 = 0; x = 0 \text{ or } x = 3$$

$$44. x^3 + 3x^2 - 70x = 0; x(x^2 + 3x - 70) = 0;$$

$$x(x - 7)(x + 10) = 0; x = 0 \text{ or } x - 7 = 0 \text{ or } x + 10 = 0;$$

$$x = 0 \text{ or } x = 7 \text{ or } x = -10$$

$$45. 3x^3 - 30x^2 + 27x = 0;$$

$$3x(x^2 - 10x + 9) = 0; 3x(x - 1)(x - 9) = 0; 3x = 0 \text{ or}$$

$$x - 1 = 0 \text{ or } x - 9 = 0; x = 0 \text{ or } x = 1 \text{ or } x = 9$$

$$46. 2x^3 = -2x^2 + 40x; 2x^3 + 2x^2 - 40x = 0;$$

$$2x(x^2 + x - 20) = 0; 2x(x - 4)(x + 5) = 0; 2x = 0 \text{ or}$$

$$x - 4 = 0 \text{ or } x + 5 = 0; x = 0 \text{ or } x = 4 \text{ or } x = -5$$

$$47. \text{length} = 5 + x + 5 = x + 10; \text{width} = 3 + x + 3 = x + 6; 124 = (x + 10)(x + 6) - 2x - 2x;$$

$$x^2 + 16x + 60 - 4x - 124 = 0; x^2 + 12x - 64 = 0;$$

$$(x - 4)(x + 16) = 0; x - 4 = 0 \text{ or } x + 16 = 0; x = 4$$

or $x = -16$, use $x = 4$

48. Answers may vary. Samples are given. 48a. $(x + 5)(x - 8) = 0; x^2 - 3x - 40 = 0$

48b. $(x - 3)(x + 2) = 0; x^2 - x - 6 = 0$

48c. $(x - \frac{1}{2})(x + 10) = 0; x^2 + \frac{19}{2}x - 5 = 0$

48d. $(3x - 2)(7x + 5) = 0$

49. $x^3 + 5x^2 - x - 5 = 0$

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

$(x - 1)(x + 1)(x + 5) = 0; x - 1 = 0 \text{ or } x + 1 = 0$

or $x + 5 = 0; x = 1 \text{ or } x = -1 \text{ or } x = -5$

50. $x^3 + x^2 - 4x - 4 = 0; x^2(x + 1) - 4(x + 1) = 0$

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

$x - 2 = 0 \text{ or } x + 2 = 0 \text{ or } x + 1 = 0; x = 2 \text{ or } x = -2$

or $x = -1$

51. $(x - 7)(2x + 8) = 0; x - 7 = 0 \text{ or}$

$2x + 8 = 0; x = 7 \text{ or } 2x = -8; x = 7 \text{ or } x = -4$; D

52. $4x^2 - 35x - 9 = 0; (4x + 1)(x - 9) = 0; 4x + 1 = 0$

or $x - 9 = 0; 4x = -1 \text{ or } x = 9; x = -\frac{1}{4} \text{ or } x = 9$; sum of solutions: $-\frac{1}{4} + 9 = 8\frac{3}{4} = 8.75$; H

53. A. Test -3:

$$-3(2(-3) - 5)(10(-3) + 3) = -3(-11)(-27) = -891 \neq 0.$$

B. Test -0.3: $(-0.3)(2(-0.3) - 5)(10(-0.3) + 3) =$

$$(-0.3)(-5.6)(0) = 0.$$

C. Test 0: $0(2(0) - 5)(10(0) + 3) = 0(-5)(3) = 0.$

D. Test 2.5: $2.5(2(2.5) - 5)(10(2.5) + 3) = 2.5(0)(28) = 0.$ The answer is A.

54. $3x^2 = 11$ has two solutions, and $5y^2 = 12$ has two solutions, so the answer is C.

55. $2n^2$ and $(2n)^2$; the answer is D.

56. [2] $3x^2 + 20x + 1 = 8; 3x^2 + 20x - 7 = 0$

$(3x - 1)(x + 7) = 0; x = \frac{1}{3}, x = -7$ [1] appropriate methods, but with one computational error

57. $x^2 = 320; x = \sqrt{320} \approx 17.9; 17.9 \text{ ft}$

$r^2 = \frac{38}{\pi}; r = \sqrt{\frac{38}{\pi}} \approx 3.5; 3.5 \text{ ft}$

59. $2x^2 + 13x + 15 = (2x + 3)(x + 5)$

60. $3y^2 - 10y + 3 = (3y - 1)(y - 3)$

61. $4t^2 + 5t - 6 = (4t - 3)(t + 2)$

62. $6n^2 + 7n - 3 = (3n - 1)(2n + 3)$

63. $15a^3 - 50a^2 - 40a = 5a(3a^2 - 10a - 8) = 5a(3a + 2)(a - 4)$

64. $-18b^3 + 42b^2 - 20b = -2b(9b^2 - 21b + 10) =$

$-2b(3b - 2)(3b - 5)$

10-6 Completing the Square

pages 541–546

Check Skills You'll Need For complete solutions see Daily Skills Check and Lesson Quiz Transparencies or Presentation Pro CD-ROM.

1. $d^2 - 8d + 16$ 2. $x^2 + 22x + 121$ 3. $k^2 - 16k + 64$

4. $(b + 5)^2$ 5. $(t + 7)^2$ 6. $(n - 9)^2$

Check Understanding 1. $\left(\frac{-22}{2}\right)^2 = (-11)^2 = 121$

2. $m^2 - 6m = 247; m^2 - 6m + 9 = 247 + 9; (m - 3)^2 =$

$256; m - 3 = \pm\sqrt{256} = \pm 16; m - 3 = 16$ or

$m - 3 = -16; m = 19$ or $m = -13$ **3a.** $x^2 + 5x + 3 = 0;$
 $x^2 + 5x = -3; x^2 + 5x + \frac{25}{4} = -3 + \frac{25}{4}; (x + \frac{5}{2})^2 = \frac{13}{4};$
 $x + \frac{5}{2} = \pm\sqrt{\frac{13}{4}} \approx \pm 1.80; x \approx -\frac{5}{2} + 1.80 \text{ or } x \approx$
 $-\frac{5}{2} - 1.80; x \approx -0.70 \text{ or } x \approx -4.30$ **3b.** $x^2 - 14x + 16 =$
 $0; x^2 - 14x = -16; x^2 - 14x + 49 = -16 + 49; (x - 7)^2 =$
 $33; x - 7 = \pm\sqrt{33} \approx \pm 5.74; x \approx 7 + 5.74 \text{ or } x \approx$
 $7 - 5.74; x \approx 12.74 \text{ or } x \approx 1.26$ **4a.** $4a^2 - 8a = 24;$
 $a^2 - 2a = 6; a^2 - 2a + 1 = 6 + 1; (a - 1)^2 = 7;$
 $a - 1 = \pm\sqrt{7} \approx \pm 2.65; a \approx 1 + \sqrt{7} \text{ or } a \approx 1 - \sqrt{7};$
 $a \approx 3.65 \text{ or } a \approx -1.65$ **4b.** $5n^2 - 3n - 15 = 10;$
 $5n^2 - 3n = 25; n^2 - \frac{3}{5}n = 5; n^2 - \frac{3}{5}n + \frac{9}{100} = 5 + \frac{9}{100};$
 $(n - \frac{3}{10})^2 = \frac{509}{100}; n - \frac{3}{10} = \pm\sqrt{\frac{509}{100}} \approx \pm 2.26;$
 $n \approx \frac{3}{10} + 2.26 \text{ or } n \approx \frac{3}{10} - 2.26; n \approx 2.56 \text{ or } n \approx -1.96$
Exercises **1.** $(\frac{14}{2})^2 = 7^2 = 49$ **2.** $(-\frac{8}{2})^2 = (-4)^2 = 16$
3. $(-\frac{40}{2})^2 = (-20)^2 = 400$ **4.** $(-\frac{6}{2})^2 = (-3)^2 = 9$
5. $(\frac{24}{2})^2 = 12^2 = 144$ **6.** $(-\frac{36}{2})^2 = (-18)^2 = 324$
7. $r^2 + 8r = 48; r^2 + 8r + 16 = 48 + 16; (r + 4)^2 = 64;$
 $r + 4 = \pm\sqrt{64} = \pm 8; r + 4 = 8 \text{ or } r + 4 = -8; r = 4 \text{ or }$
 $r = -12$ **8.** $x^2 - 10x = 40; x^2 - 10x + 25 = 40 + 25;$
 $(x - 5)^2 = 65; x - 5 = \pm\sqrt{65}; x - 5 = \sqrt{65} \text{ or }$
 $x - 5 = -\sqrt{65}; x = 5 + \sqrt{65} \approx 13.06 \text{ or } x =$
 $5 - \sqrt{65} \approx -3.06$ **9.** $q^2 + 22q = -85; q^2 + 22q + 121 =$
 $-85 + 121; (q + 11)^2 = 36; q + 11 = \pm\sqrt{36} = \pm 6;$
 $q + 11 = 6 \text{ or } q + 11 = -6; q = -5 \text{ or } q = -17$
10. $m^2 + 6m = 9; m^2 + 6m + 9 = 9 + 9; (m + 3)^2 = 18;$
 $m + 3 = \pm\sqrt{18}; m + 3 = \sqrt{18} \text{ or } m + 3 = -\sqrt{18};$
 $m = -3 + \sqrt{18} \approx 1.24 \text{ or } m = -3 - \sqrt{18} \approx -7.24$
11. $r^2 + 20r = 261; r^2 + 20r + 100 = 261 + 100;$
 $(r + 10)^2 = 361; r + 10 = \pm\sqrt{361} = \pm 19; r + 10 = 19 \text{ or }$
 $r + 10 = -19; r = 9 \text{ or } r = -29$ **12.** $g^2 - 2g = 323;$
 $g^2 - 2g + 1 = 323 + 1; (g - 1)^2 = 324; g - 1 =$
 $\pm\sqrt{324} = \pm 18; g - 1 = 18 \text{ or } g - 1 = -18; g = 19 \text{ or }$
 $g = -17$ **13.** $r^2 - 2r - 35 = 0; r^2 - 2r = 35;$
 $r^2 - 2r + 1 = 35 + 1; (r - 1)^2 = 36; r - 1 = \pm\sqrt{36} =$
 $\pm 6; r - 1 = 6 \text{ or } r - 1 = -6; r = 7 \text{ or } r = -5$
14. $x^2 + 10x + 17 = 0; x^2 + 10x = -17; x^2 + 10x + 25 =$
 $-17 + 25; (x + 5)^2 = 8; x + 5 = \pm\sqrt{8} \approx \pm 2.83; x + 5 \approx$
 $2.83 \text{ or } x + 5 \approx -2.83; x \approx -5 + 2.83 = -2.17 \text{ or } x \approx$
 $-5 - 2.83 = -7.83$ **15.** $p^2 - 12p + 11 = 0; p^2 - 12p =$
 $-11; p^2 - 12p + 36 = -11 + 36; (p - 6)^2 = 25; p - 6 =$
 $\pm\sqrt{25} = \pm 5; p - 6 = 5 \text{ or } p - 6 = -5; p = 11 \text{ or } p = 1$
16. $w^2 + 3w - 5 = 0; w^2 + 3w = 5; w^2 + 3w + \frac{9}{4} = 5 + \frac{9}{4};$
 $(w + \frac{3}{2})^2 = \frac{29}{4}; w + \frac{3}{2} = \pm\sqrt{\frac{29}{4}} \approx \pm 2.69; w + \frac{3}{2} \approx$
 $2.69 \text{ or } w + \frac{3}{2} \approx -2.69; w \approx 2.69 - 1.5 = 1.19 \text{ or } w \approx$
 $-2.69 - 1.5 = -4.19$ **17.** $m^2 + m - 28 = 0; m^2 + m =$
 $28; m^2 + m + \frac{1}{4} = 28 + \frac{1}{4}; (m + \frac{1}{2})^2 = \frac{113}{4};$

$m + \frac{1}{2} = \pm\sqrt{\frac{113}{4}} \approx \pm 5.32; m + \frac{1}{2} \approx 5.32 \text{ or } m + \frac{1}{2} \approx$
 $-5.32; m \approx -0.5 + 5.32 = 4.82 \text{ or } m \approx -0.5 - 5.32 =$
 -5.82 **18.** $a^2 + 9a - 682 = 0; a^2 + 9a = 682;$
 $a^2 + 9a + \frac{81}{4} = 682 + \frac{81}{4}; (a + \frac{9}{2})^2 = \frac{2809}{4}; a + \frac{9}{2} =$
 $\pm\sqrt{\frac{2809}{4}} = \pm 26.5; a + \frac{9}{2} = 26.5 \text{ or } a + \frac{9}{2} = -26.5;$
 $a = -4.5 + 26.5 = 22 \text{ or } a = -4.5 - 26.5 = -31$
19. $2k^2 + 4k = 10; k^2 + 2k = 5; k^2 + 2k + 1 = 5 + 1;$
 add 1. **20.** $3x^2 + 12x = 24; x^2 + 4x = 8; x^2 + 4x + 4 =$
 $8 + 4; \text{add 4.}$ **21.** $5t^2 + 9t = 15; t^2 + \frac{9}{5}t = 3;$
 $t^2 + \frac{9}{5}t + \frac{81}{100} = 3 + \frac{81}{100}; \text{add } \frac{81}{100}$ **22.** $4y^2 + 8y - 36 = 0;$
 $y^2 + 2y = 9; y^2 + 2y + 1 = 9 + 1; (y + 1)^2 = 10;$
 $y + 1 = \pm\sqrt{10} \approx \pm 3.16; y + 1 \approx 3.16 \text{ or } y + 1 \approx$
 $-3.16; y \approx -1 + 3.16 = 2.16 \text{ or } y \approx -1 - 3.16 = -4.16$
23. $3q^2 - 12q = 15; q^2 - 4q = 5; q^2 - 4q + 4 = 5 + 4;$
 $(q - 2)^2 = 9; q - 2 = \pm\sqrt{9} = \pm 3; q - 2 = 3 \text{ or } q - 2 =$
 $-3; q = 5 \text{ or } q = -1$ **24.** $2x^2 - 10x - 20 = 8;$
 $2x^2 - 10x = 28; x^2 - 5x = 14; x^2 - 5x + \frac{25}{4} = 14 + \frac{25}{4};$
 $(x - \frac{5}{2})^2 = \frac{81}{4}; x - \frac{5}{2} = \pm\sqrt{\frac{81}{4}} = \pm\frac{9}{2}; x - \frac{5}{2} = \frac{9}{2} \text{ or }$
 $x - \frac{5}{2} = -\frac{9}{2}; x = \frac{14}{2} = 7 \text{ or } x = -\frac{4}{2} = -2$ **25a.** length:
 $1 + x + x = 2x + 1; \text{width: } x + 1; \text{area: } (2x + 1)(x + 1)$
25b. $(2x + 1)(x + 1) = 28; 2x^2 + 3x + 1 = 28$
25c. $2x^2 + 3x = 27; x^2 + \frac{3}{2}x = \frac{27}{2}; x^2 + \frac{3}{2}x + \frac{9}{16} =$
 $\frac{27}{2} + \frac{9}{16}; (x + \frac{3}{4})^2 = \frac{225}{16}; x + \frac{3}{4} = \pm\sqrt{\frac{225}{16}} = \pm\frac{15}{4};$
 $x + \frac{3}{4} = \frac{15}{4} \text{ or } x + \frac{3}{4} = -\frac{15}{4}; x = \frac{12}{4} = 3 \text{ or } x = -\frac{18}{4} =$
 $-4\frac{1}{2}, \text{use } x = 3$ **26.** $b^2 + 4b + 1 = 0; b^2 + 4b = -1;$
 $b^2 + 4b + 4 = -1 + 4; (b + 2)^2 = 3; b + 2 = \pm\sqrt{3} \approx$
 $\pm 1.73; b + 2 \approx 1.73 \text{ or } b + 2 \approx -1.73; b \approx$
 $-2 + 1.73 = -0.27 \text{ or } b \approx -2 - 1.73 = -3.73$
27. $c^2 + 7c = -12; c^2 + 7c + \frac{49}{4} = -12 + \frac{49}{4};$
 $(c + \frac{7}{2})^2 = \frac{1}{4}; c + \frac{7}{2} = \pm\sqrt{\frac{1}{4}} = \pm\frac{1}{2}; c + \frac{7}{2} = \frac{1}{2} \text{ or }$
 $c + \frac{7}{2} = -\frac{1}{2}; c = -\frac{6}{2} = -3 \text{ or } c = -\frac{8}{2} = -4$
28. $h^2 + 6h - 40 = 0; h^2 + 6h = 40; h^2 + 6h + 9 =$
 $40 + 9; (h + 3)^2 = 49; h + 3 = \pm\sqrt{49} = \pm 7; h + 3 = 7$
 $\text{or } h + 3 = -7; h = 4 \text{ or } h = -10$ **29.** $y^2 - 8y = -12;$
 $y^2 - 8y + 16 = -12 + 16; (y - 4)^2 = 4; y - 4 =$
 $\pm\sqrt{4} = \pm 2; y - 4 = 2 \text{ or } y - 4 = -2; y = 6 \text{ or } y = 2$
30. $4m^2 - 40m + 56 = 0; 4m^2 - 40m = -56; m^2 - 10m =$
 $-14; m^2 - 10m + 25 = -14 + 25; (m - 5)^2 = 11;$
 $m - 5 = \pm\sqrt{11} \approx \pm 3.32; m - 5 \approx 3.32 \text{ or } m - 5 \approx$
 $-3.32; m \approx 5 + 3.32 = 8.32 \text{ or } m \approx 5 - 3.32 = 1.68$
31. $k^2 + 4k + 11 = -10; k^2 + 4k = -21; k^2 + 4k + 4 =$
 $-21 + 4; (k + 2)^2 = -17; \text{no solution}$
32. $2x^2 - 15x + 6 = 41; 2x^2 - 15x = 35; x^2 - \frac{15}{2}x = \frac{35}{2};$
 $x^2 - \frac{15}{2}x + \frac{225}{16} = \frac{35}{2} + \frac{225}{16}; (x - \frac{15}{4})^2 = \frac{505}{16};$
 $x - \frac{15}{4} = \pm\sqrt{\frac{505}{16}} \approx \pm 5.62; x - 3.75 = 5.62 \text{ or }$
 $x - 3.75 \approx -5.62; x \approx 3.75 + 5.62 = 9.37 \text{ or } x \approx$
 $3.75 - 5.62 = -1.87$ **33.** $3d^2 - 24d = 3; d^2 - 8d = 1;$

$d^2 - 8d + 16 = 1 + 16$; $(d - 4)^2 = 17$; $d - 4 = \pm\sqrt{17} \approx \pm 4.12$; $d - 4 \approx 4.12$ or $d - 4 \approx -4.12$; $d \approx 4 + 4.12 = 8.12$ or $d \approx 4 - 4.12 = -0.12$ 34. $x^2 + 9x + 20 = 0$; $x^2 + 9x = -20$; $x^2 + 9x + \frac{81}{4} = -20 + \frac{81}{4}$; $\left(x + \frac{9}{2}\right)^2 = \frac{1}{4}$; $x + \frac{9}{2} = \pm\sqrt{\frac{1}{4}} = \pm\frac{1}{2}$; $x + \frac{9}{2} = \frac{1}{2}$ or $x + \frac{9}{2} = -\frac{1}{2}$; $x = -\frac{8}{2} = -4$ or $x = -\frac{10}{2} = -5$ 35a. $\ell + 2w = 50$; $\ell = 50 - 2w$ 35b. $w\ell = 150$; $w(50 - 2w) = 150$; $-2w^2 + 50w = 150$; $w^2 - 25w = -75$; $w^2 - 25w + \frac{625}{4} = -75 + \frac{625}{4}$; $\left(w - \frac{25}{2}\right)^2 = \frac{325}{4}$; $w - \frac{25}{2} = \pm\sqrt{\frac{325}{4}} \approx \pm 9.0$; $w - 12.5 \approx 9.0$ or $w - 12.5 \approx -9.0$; $w \approx 12.5 + 9.0 = 21.5$ or $w \approx 12.5 - 9.0 = 3.5$ 35c. If $w = 21.5$, then $\ell = 50 - 2(21.5) = 7$, so 7 ft \times 21.5 ft. Or, if $w = 3.5$, then $\ell = 50 - 2(3.5) = 43$, so 43 ft \times 3.5 ft. 35d. $7(21.5) = 150.5$, and $43(3.5) = 150.5$; no, because the answers in part (b) were rounded. 36. The student did not divide each side of the equation by 4.

37. Answers may vary. Sample: Add 1 to each side of the equation, and then complete the square by adding 225 to each side of the equation. Write $x^2 + 30x + 225$ as the square $(x + 15)^2$ and add 1 and 225 to get 226. Then take square roots and solve the resulting equations.

38. Answers may vary. Sample: $x^2 + 10x - 50 = 0$; $x^2 + 10x = 50$; $x^2 + 10x + 25 = 50 + 25$; $(x + 5)^2 = 75$; $x + 5 = \pm\sqrt{75} \approx \pm 8.7$; $x + 5 \approx 8.7$ or $x + 5 \approx -8.7$; $x \approx 3.7$ or $x \approx -13.7$ 39. Estimates may vary. Sample: Locate $\approx (-1, 5)$ and $\approx (5, 5)$, so the values of x are about -1 and 5. Equation: $x^2 - 4x - 1 = 5$; $x^2 - 4x = 6$; $x^2 - 4x + 4 = 6 + 4$; $(x - 2)^2 = 10$; $x - 2 = \pm\sqrt{10} \approx \pm 3.16$; $x - 2 \approx 3.16$ or $x - 2 \approx -3.16$; $x \approx 5.16$ or $x \approx -1.16$ 40. Estimates may vary. Sample: Locate $\approx (1, 5)$ and $\approx (7, 5)$, so the values of x are about 1 and 7.

Equation: $-\frac{1}{2}x^2 + 4x + 1 = 5$; $-\frac{1}{2}x^2 + 4x = 4$; $x^2 - 8x = -8$; $x^2 - 8x + 16 = -8 + 16$; $(x - 4)^2 = 8$; $x - 4 = \pm\sqrt{8} \approx \pm 2.83$; $x - 4 \approx 2.83$ or $x - 4 \approx -2.83$; $x \approx 6.83$ or $x \approx 1.17$ 41. length = x , width = $2x + 3$; Area = ℓw ; $x(2x + 3) = 80$; $2x^2 + 3x = 80$; $x^2 + \frac{3}{2}x = 40$; $x^2 + \frac{3}{2}x + \frac{9}{16} = 40 + \frac{9}{16}$; $\left(x + \frac{3}{4}\right)^2 = \frac{649}{16}$; $x + \frac{3}{4} = \pm\sqrt{\frac{649}{16}} \approx \pm 6.37$; $x + 0.75 \approx 6.37$ or $x + 0.75 \approx -6.37$; $x \approx 5.62$ or $x \approx -7.12$, use $x \approx 5.62 \approx 5.6$; width = $x = 5.6$, and length = $2x + 3 = 2(5.6) + 3 = 14.2$; 5.6 ft by 14.2 ft 42a. $2[x(x + 7) + x^2 + x(x + 7)] = 2(x^2 + 7x + x^2 + x^2 + 7x) = 2(3x^2 + 14x) = 6x^2 + 28x$ 42b. $6x^2 + 28x = 6 \cdot 8^2$; $6x^2 + 28x = 384$ 42c. $x^2 + \frac{28}{6}x = \frac{384}{6}$; $x^2 + \frac{14}{3}x = 64$; $x^2 + \frac{14}{3}x + \frac{196}{36} = 64 + \frac{196}{36}$; $\left(x + \frac{7}{3}\right)^2 = \frac{2500}{36}$; $x + \frac{7}{3} = \pm\sqrt{\frac{2500}{36}} = \pm\frac{50}{6} = \pm\frac{25}{3}$; $x + \frac{7}{3} = \frac{25}{3}$ or $x + \frac{7}{3} = -\frac{25}{3}$; $x = \frac{18}{3} = 6$ or $x = -\frac{32}{3}$, use $x = 6$; $x + 7 = 6 + 7 = 13$; 13 in. \times 6 in. \times 6 in.

43a. length = $1 + x + x + x + x = 4x + 1$, width = $x + 1$, area to subtract out = $\frac{1}{2}x^2$; $A = (4x + 1)(x + 1) - \frac{1}{2}x^2 = 4x^2 + 5x + 1 - \frac{1}{2}x^2 = \frac{7}{2}x^2 + 5x + 1$ 43b. $\frac{7}{2}x^2 + 5x + 1 = 200$; $\frac{7}{2}x^2 + 5x = 199$;

$x^2 + \frac{10}{7}x = \frac{398}{7}$; $x^2 + \frac{10}{7}x + \frac{100}{196} = \frac{398}{7} + \frac{100}{196}$; $\left(x + \frac{5}{7}\right)^2 = \frac{11,244}{196}$; $x + \frac{5}{7} = \pm\sqrt{\frac{11,244}{196}} \approx \pm 7.57$; $x + \frac{5}{7} \approx 7.57$ or $x + \frac{5}{7} \approx -7.57$; $x \approx 6.86$ or $x \approx -8.28$, use $x \approx 6.86$ 43c. $x \approx 6.86 \approx 7$; $A \approx \frac{7}{2} \cdot 7^2 + 5 \cdot 7 + 1 = 207.5$; 207.5 ft² 44a. $x^2 - 6x + 4 = 0$; $x^2 - 6x = -4$; $x^2 - 6x + 9 = -4 + 9$; $(x - 3)^2 = 5$; $x - 3 = \pm\sqrt{5}$; $x = 3 \pm \sqrt{5}$ 44b. $y = x^2 - 6x + 4$; $x = -\frac{b}{2a} = -\frac{-6}{2(1)} = 3$; $y = 3^2 - 6(3) + 4 = -5$; vertex (3, -5) 44c. Answers may vary. Sample: p is the x -coordinate of the vertex. 45. $x^2 + bx + 100; 2\sqrt{100} = 2(10) = 20$; B 46. $F. t^2 - 14t + 49 = (t - 7)^2$ G. $9b^2 + 66b + 121 = (3b + 11)^2$ H. $4m^2 - 24m + 36 = (2m - 6)^2$ I. $81k^2 - 120k + 100 \neq (9k - 10)^2$; the answer is I. 47. $x^2 + 6x - 11 = 0$; $x^2 + 6x = 11$; $x^2 + 6x + 9 = 11 + 9$; $(x + 3)^2 = 20$; $x + 3 = \pm\sqrt{20} \approx \pm 4.47$; $x + 3 \approx 4.47$ or $x + 3 \approx -4.47$; $x \approx 1.47$ or $x \approx -7.47$; D 48. $[2] \frac{1}{2}(x)(x + x + 4) = 200$; $\frac{1}{2}(x)(2x + 4) = 200$; $(x)(x + 2) = 200$; $x^2 + 2x = 200$; $x^2 + 2x + 1 = 201$; $(x + 1)^2 = 201$; $x + 1 \approx \pm 14.18$; $x = 13.18$ or $x = -15.18$; The value of x is about 13.18 cm. [1] appropriate methods, but with one computational error 49. [4] 49a. $(8 + x)(12 + x) = 2 \cdot (8 \cdot 12)$; $x^2 + 20x + 96 = 0$ 49b. $x^2 + 20x = 96$; $x^2 + 20x + 100 = 196$; $(x + 10)^2 = 196$; $x + 10 = \pm 14$; $x = 4$ 49c. 12 ft by 16 ft [3] appropriate methods, but with one computational error [2] part (c) not done [1] no work shown 50. $x^2 - 4x - 21 = 0$; $(x + 3)(x - 7) = 0$; $x + 3 = 0$ or $x - 7 = 0$; $x = -3$ or $x = 7$ 51. $n^2 + 11n + 30 = 0$; $(n + 6)(n + 5) = 0$; $n + 6 = 0$ or $n + 5 = 0$; $n = -6$ or $n = -5$ 52. $t^2 - 5t = 0$; $t(t - 5) = 0$; $t = 0$ or $t - 5 = 0$; $t = 0$ or $t = 5$ 53. $9v^2 - 64 = 0$; $(3v - 8)(3v + 8) = 0$; $3v - 8 = 0$ or $3v + 8 = 0$; $3v = 8$ or $3v = -8$; $v = \frac{8}{3}$ or $v = -\frac{8}{3}$ 54. $4c^2 + 12c = -9$; $4c^2 + 12c + 9 = 0$; $(2c + 3)(2c + 3) = 0$; $2c + 3 = 0$; $2c = -3$; $c = -\frac{3}{2}$ 55. $12w^2 = 28w + 5$; $12w^2 - 28w - 5 = 0$; $(6w + 1)(2w - 5) = 0$; $6w + 1 = 0$ or $2w - 5 = 0$; $6w = -1$ or $2w = 5$; $w = -\frac{1}{6}$ or $w = \frac{5}{2}$ 56. $x^2 + 4x + 4 = x^2 + 2(2x) + 2^2 = (x + 2)^2$ 57. $t^2 - 22t + 121 = t^2 - 2(11t) + 11^2 = (t - 11)^2$ 58. $b^2 - 25 = b^2 - 5^2 = (b + 5)(b - 5)$ 59. $16c^2 + 24c + 9 = (4c)^2 + 2(4c)(3) + 3^2 = (4c + 3)^2$ 60. $49s^2 - 169 = (7s)^2 - 13^2 = (7s + 13)(7s - 13)$ 61. $8m^3 - 18m = 2m(4m^2 - 9) = 2m((2m)^2 - 3^2) = 2m(2m + 3)(2m - 3)$ 62. $25m^2 + 120m + 144 = (5m)^2 + 2(5m)(12) + 12^2 = (5m + 12)^2$ 63. $400k^2 - 9 = (20k)^2 - 3^2 = (20k + 3)(20k - 3)$ 64. $256g^2 - 121 = (16g)^2 - 11^2 = (16g + 11)(16g - 11)$ 65. $(r^3)^4 = r^{3 \cdot 4} = r^{12}$ 66. $p(p^2)^6 = p(p^{2 \cdot 6}) = p(p^{12}) = p^{1+12} = p^{13}$ 67. $-y^3(y^{-1})^2 = -y^3y^{-2} = -\frac{y^3}{y^2} = -y$ 68. $(m^5)^{-8} = m^{-40} = \frac{1}{m^{40}}$ 69. $-w^7(w^8)^{-1} = -w^7w^{-8} = -\frac{w^7}{w^8} = -\frac{1}{w}$ 70. $t^8(t^{-7})^{-3} = t^8t^{21} = t^{8+21} = t^{29}$

10-7 Using the Quadratic Formula

pages 547–552

Check Skills You'll Need For complete solutions see Daily Skills Check and Lesson Quiz Transparencies or Presentation Pro CD-ROM.

1. 9 2. $\frac{49}{4}$ 3. $\frac{81}{4}$ 4. 6, 4 5. 2, -18 6. 1, -5 7. -7, 8

Check Understanding 1a. $x^2 - 2x - 8 = 0; a = 1,$

$$b = -2, c = -8; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$$

$$\frac{-(-2) \pm \sqrt{(-2)^2 - 4(1)(-8)}}{2(1)} = \frac{2 \pm \sqrt{36}}{2} = \frac{2 \pm 6}{2} = 1 \pm 3;$$

$$x = 1 + 3 = 4 \text{ or } x = 1 - 3 = -2$$

$$1b. x^2 - 4x = 117; x^2 - 4x - 117 = 0; a = 1, b = -4, c = -117; x =$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(1)(-117)}}{2(1)} =$$

$$\frac{4 \pm \sqrt{484}}{2} = \frac{4 \pm 22}{2} = 2 \pm 11; x = 2 + 11 = 13 \text{ or } x =$$

$$2 - 11 = -9$$

$$2a. -3x^2 + 5x - 2 = 0; a = -3, b = 5, c = -2; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-5 \pm \sqrt{5^2 - 4(-3)(-2)}}{2(-3)} =$$

$$\frac{-5 \pm \sqrt{1}}{-6} = \frac{-5 \pm 1}{-6}; x = \frac{-5 + 1}{-6} = \frac{2}{3} \approx 0.67 \text{ or } x =$$

$$\frac{-5 - 1}{-6} = 1$$

$$2b. 7x^2 - 2x - 8 = 0; a = 7, b = -2, c = -8; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-2) \pm \sqrt{(-2)^2 - 4(7)(-8)}}{2(7)} =$$

$$\frac{2 \pm \sqrt{228}}{14}; x \approx \frac{2 + 15.10}{14} \approx 1.22 \text{ or } x \approx \frac{2 - 15.10}{14} \approx -0.94$$

$$3a. 0 = -16t^2 + 38.4t + 3.5$$

$$3b. a = -16, b = 38.4, c = 3.5; t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$$

$$\frac{-38.4 \pm \sqrt{38.4^2 - 4(-16)(3.5)}}{2(-16)} = \frac{-38.4 \pm \sqrt{1698.56}}{-32}; t \approx$$

$$\frac{-38.4 + 41.21}{-32} \approx -0.1 \text{ or } t \approx \frac{-38.4 - 41.21}{-32} \approx 2.5; 2.5 \text{ s}$$

4a. Quadratic formula; the equation cannot be factored easily. 4b. Factoring; the equation is easily factorable.

4c. Square roots; there is no x term.

Exercises 1. $2x^2 + 5x + 3 = 0; a = 2, b = 5, c = 3;$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-5 \pm \sqrt{5^2 - 4(2)(3)}}{2(2)} =$$

$$\frac{-5 \pm \sqrt{1}}{4} = \frac{-5 \pm 1}{4}; x = \frac{-5 + 1}{4} = -1 \text{ or } x = \frac{-5 - 1}{4} =$$

$$-1.5$$

$$2. 5x^2 + 16x - 84 = 0; a = 5, b = 16, c = -84; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-16 \pm \sqrt{16^2 - 4(5)(-84)}}{2(5)} =$$

$$\frac{-16 \pm \sqrt{1936}}{10} = \frac{-16 \pm 44}{10}; x = \frac{-16 + 44}{10} = 2.8 \text{ or } x =$$

$$\frac{-16 - 44}{10} = -6$$

$$3. 4x^2 - 12x + 9 = 0; a = 4, b = -12, c = 9; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-12) \pm \sqrt{(-12)^2 - 4(4)(9)}}{2(4)} =$$

$$\frac{12 \pm \sqrt{0}}{8} = \frac{12}{8} = 1.5$$

$$4. 3x^2 + 47x = -30;$$

$$3x^2 + 47x + 30 = 0; a = 3, b = 47, c = 30;$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-47 \pm \sqrt{47^2 - 4(3)(30)}}{2(3)} =$$

$$\frac{-47 \pm \sqrt{1849}}{6} = \frac{-47 \pm 43}{6}; x = \frac{-47 + 43}{6} \approx -0.67 \text{ or } x =$$

$$\frac{-47 - 43}{6} = -15$$

$$5. 12x^2 - 77x - 20 = 0; a = 12, b = -77, c = -20; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$$

$$-\frac{(-77) \pm \sqrt{(-77)^2 - 4(12)(-20)}}{2(12)} = \frac{77 \pm \sqrt{6889}}{24} = \frac{77 \pm 83}{24},$$

$$x = \frac{77 + 83}{24} \approx 6.67 \text{ or } x = \frac{77 - 83}{24} = -0.25$$

$$6. 3x^2 + 39x + 108 = 0; a = 3, b = 39, c = 108;$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-39 \pm \sqrt{39^2 - 4(3)(108)}}{2(3)} =$$

$$\frac{-39 \pm \sqrt{225}}{6} = \frac{-39 \pm 15}{6}; x = \frac{-39 + 15}{6} = -4 \text{ or } x =$$

$$\frac{-39 - 15}{6} = -9$$

$$7. 3x^2 + 40x - 128 = 0; a = 3, b = 40, c = -128; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$$

$$\frac{-40 \pm \sqrt{40^2 - 4(3)(-128)}}{2(3)} = \frac{-40 \pm \sqrt{3136}}{6} = \frac{-40 \pm 56}{6},$$

$$x = \frac{-40 + 56}{6} \approx 2.67 \text{ or } x = \frac{-40 - 56}{6} = -16$$

$$8. 2x^2 - 9x - 221 = 0; a = 2, b = -9, c = -221; x =$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-9) \pm \sqrt{(-9)^2 - 4(2)(-221)}}{2(2)} =$$

$$\frac{9 \pm \sqrt{1849}}{4} = \frac{9 \pm 43}{4}; x = \frac{9 + 43}{4} = 13 \text{ or } x = \frac{9 - 43}{4} = -8.5$$

$$9. 5x^2 - 68x = 192; 5x^2 - 68x - 192 = 0; a = 5,$$

$$b = -68, c = -192; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$$

$$\frac{-(-68) \pm \sqrt{(-68)^2 - 4(5)(-192)}}{2(5)} = \frac{68 \pm \sqrt{8464}}{10} =$$

$$\frac{68 \pm 92}{10}; x = \frac{68 + 92}{10} = 16 \text{ or } x = \frac{68 - 92}{10} = -2.4$$

$$10. 5x^2 + 13x - 1 = 0; a = 5, b = 13, c = -1; x =$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-13 \pm \sqrt{13^2 - 4(5)(-1)}}{2(5)} = \frac{-13 \pm \sqrt{189}}{10},$$

$$x = \frac{-13 + \sqrt{189}}{10} \approx 0.07 \text{ or } x = \frac{-13 - \sqrt{189}}{10} \approx -2.67$$

$$11. 2x^2 - 24x + 33 = 0; a = 2, b = -24, c = 33; x =$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-24) \pm \sqrt{(-24)^2 - 4(2)(33)}}{2(2)} =$$

$$\frac{24 \pm \sqrt{312}}{4}; x = \frac{24 \pm \sqrt{312}}{4} \approx 10.42 \text{ or } x = \frac{24 - \sqrt{312}}{4} \approx$$

$$1.58 12. 7x^2 + 100x - 4 = 0; a = 7, b = 100, c = -4; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-100 \pm \sqrt{100^2 - 4(7)(-4)}}{2(7)} =$$

$$\frac{-100 \pm \sqrt{10,112}}{14}; x = \frac{-100 + \sqrt{10,112}}{14} \approx 0.04 \text{ or } x =$$

$$\frac{-100 - \sqrt{10,112}}{14} \approx -14.33$$

$$13. 8x^2 - 3x - 7 = 0; a = 8, b = -3, c = -7; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$$

$$\frac{-(-3) \pm \sqrt{(-3)^2 - 4(8)(-7)}}{2(8)} = \frac{3 \pm \sqrt{233}}{16}; x =$$

$$\frac{3 + \sqrt{233}}{16} \approx 1.14 \text{ or } x = \frac{3 - \sqrt{233}}{16} \approx -0.77$$

$$14. 6x^2 + 5x - 40 = 0; a = 6, b = 5, c = -40; x =$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-5 \pm \sqrt{5^2 - 4(6)(-40)}}{2(6)} = \frac{-5 \pm \sqrt{985}}{12},$$

$$x = \frac{-5 + \sqrt{985}}{12} \approx 2.20 \text{ or } x = \frac{-5 - \sqrt{985}}{12} \approx -3.03$$

$$15. 3x^2 - 11x - 2 = 0; a = 3, b = -11, c = -2; x =$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-11) \pm \sqrt{(-11)^2 - 4(3)(-2)}}{2(3)} =$$

$$\frac{11 \pm \sqrt{145}}{6}; x = \frac{11 \pm \sqrt{145}}{6} \approx 3.84 \text{ or } x = \frac{11 - \sqrt{145}}{6} \approx$$

$$-0.17$$

$$16a. 0 = -16t^2 + 10t + 3$$

$$16b. a = -16, b = 10, c = 3; t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-10 \pm \sqrt{10^2 - 4(-16)(3)}}{2(-16)} =$$

$$\frac{-10 \pm \sqrt{292}}{-32}; t = \frac{-10 + \sqrt{292}}{-32} \approx -0.22 \text{ or }$$

$$t = \frac{-10 - \sqrt{292}}{-32} \approx 0.8; 0.8 \text{ s}$$

17a. $0 = -16t^2 + 50t + 3.5$

17b. $a = -16, b = 50, c = 3.5; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-50 \pm \sqrt{50^2 - 4(-16)(3.5)}}{2(-16)} = \frac{-50 \pm \sqrt{2724}}{-32},$

$x = \frac{-50 + \sqrt{2724}}{-32} \approx -0.1 \text{ or } x = \frac{-50 - \sqrt{2724}}{-32} \approx 3.2; 3.2 \text{ s}$

18. Completing the square or graphing; the x^2 term is 1 but the equation is not factorable.

19. Factoring or square roots; the equation is easily factorable and there is no x term. **20.** Quadratic formula; the equation cannot be factored. **21.** Quadratic formula; the equation cannot be factored. **22.** Factoring; the equation is easily factorable. **23.** Quadratic formula; the equation cannot be factored. **24.** $2t^2 = 72; t^2 = 36;$

$$t = \pm\sqrt{36} = \pm 6; t = 6 \text{ or } t = -6$$

25. $3x^2 + 2x - 4 = 0; a = 3, b = 2, c = -4; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2 \pm \sqrt{2^2 - 4(3)(-4)}}{2(3)} = \frac{-2 \pm \sqrt{52}}{6}; x = \frac{-2 + \sqrt{52}}{6} \approx 0.87$

or $x = \frac{-2 - \sqrt{52}}{6} \approx -1.54$

26. $5b^2 - 10 = 0; 5(b^2 - 2) = 0; b^2 - 2 = 0; b^2 = 2; b = \pm\sqrt{2}; b = \sqrt{2} \approx 1.41 \text{ or } b = -\sqrt{2} \approx -1.41$

27. $3x^2 + 4x = 10; 3x^2 + 4x - 10 = 0; a = 3, b = 4, c = -10; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-4 \pm \sqrt{4^2 - 4(3)(-10)}}{2(3)} = \frac{-4 \pm \sqrt{136}}{6}; x = \frac{-4 + \sqrt{136}}{6} \approx 1.28 \text{ or } x = \frac{-4 - \sqrt{136}}{6} \approx -2.61$

28. $m^2 - 4m = -4; m^2 - 4m + 4 = 0; (m - 2)^2 = 0; m - 2 = 0; m = 2$

29. $13n^2 - 117 = 0; 13(n^2 - 9) = 0; 13(n - 3)(n + 3) = 0; n - 3 = 0 \text{ or } n + 3 = 0; n = 3 \text{ or } n = -3$

30. $3s^2 - 4s = 2; 3s^2 - 4s - 2 = 0; a = 3, b = -4, c = -2; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(3)(-2)}}{2(3)} = \frac{4 \pm \sqrt{40}}{6}; x = \frac{4 + \sqrt{40}}{6} \approx 1.72 \text{ or } x = \frac{4 - \sqrt{40}}{6} \approx -0.39$

31. $5b^2 - 2b - 7 = 0; (5b - 7)(b + 1) = 0; 5b - 7 = 0 \text{ or } b + 1 = 0; 5b = 7 \text{ or } b = -1; b = \frac{7}{5} = 1.4 \text{ or } b = -1$

32. $15x^2 - 12x - 48 = 0; 3(5x^2 - 4x - 16) = 0; 5x^2 - 4x - 16 = 0; a = 5, b = -4, c = -16; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(5)(-16)}}{2(5)} = \frac{4 \pm \sqrt{336}}{10}; x = \frac{4 + \sqrt{336}}{10} \approx 2.23 \text{ or } x = \frac{4 - \sqrt{336}}{10} \approx -1.43$

33a. $7 \text{ ft} \times 8 \text{ ft}$

33b. $x(x + 1) = 60; x^2 + x - 60 = 0; a = 1, b = 1, c = -60; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-1 \pm \sqrt{1^2 - 4(1)(-60)}}{2(1)} = \frac{-1 \pm \sqrt{241}}{2}; x = \frac{-1 \pm \sqrt{241}}{2} \approx 7.26 \text{ or } x = \frac{-1 - \sqrt{241}}{2} \approx -8.26; \text{ use } x \approx 7.26 \text{ and } x + 1 \approx 7.26 + 1 = 8.26; 7.26 \text{ ft} \times 8.26 \text{ ft}$

34. $0 = -16t^2 + 30t + 6; a = -16, b = 30, c = 6; t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-30 \pm \sqrt{30^2 - 4(-16)(6)}}{2(-16)} = \frac{-30 \pm \sqrt{1284}}{-32}; t = \frac{-30 \pm \sqrt{1284}}{-32} \approx -0.2 \text{ or } t = \frac{-30 - \sqrt{1284}}{-32} \approx 2.1; \text{ about } 2.1 \text{ s}$

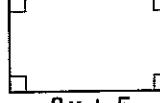
35. Answers may vary.

Sample: You solve the linear equation using transformations and you solve the quadratic equation using the quadratic formula.

36. $A = \frac{1}{2}bh; 20 = \frac{1}{2}x(x + 2); 40 = x^2 + 2x; x^2 + 2x - 40 = 0; a = 1, b = 2, c = -40; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2 \pm \sqrt{2^2 - 4(1)(-40)}}{2(1)} = \frac{-2 \pm \sqrt{164}}{2}, x = \frac{-2 + \sqrt{164}}{2} \approx 5.40 \text{ or } x = \frac{-2 - \sqrt{164}}{2} \approx 7.40; \text{ use } x \approx 5.40 \text{ and } x + 2 \approx 5.40 + 2 = 7.40; 7.40 \text{ ft and } 5.40 \text{ ft}$

37. $A = \frac{1}{2}bh; 50 = \frac{1}{2}x(x + 6); 100 = x^2 + 6x; x^2 + 6x - 100 = 0; a = 1, b = 6, c = -100; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-6 \pm \sqrt{6^2 - 4(1)(-100)}}{2(1)} = \frac{-6 \pm \sqrt{436}}{2}, x = \frac{-6 \pm \sqrt{436}}{2} \approx 7.44 \text{ or } x = \frac{-6 - \sqrt{436}}{2} \approx -13.44; \text{ use } x \approx 7.44 \text{ and } x + 6 \approx 7.44 + 6 = 13.44; 13.44 \text{ cm and } 7.44 \text{ cm}$

38. Answers may vary. Sample: A rectangle has length x . Its width is 5 ft longer than three times the length. Find the dimensions if its area is 182 ft^2 .



$x(3x + 5) = 182; 3x^2 + 5x - 182 = 0; a = 3, b = 5, c = -182; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-5 \pm \sqrt{5^2 - 4(3)(-182)}}{2(3)} = \frac{-5 \pm \sqrt{2209}}{6} = \frac{-5 \pm 47}{6}; x = \frac{-5 + 47}{6} = 7 \text{ or } x = \frac{-5 - 47}{6} \approx -8.7; \text{ use } x = 7 \text{ and } 3x + 5 = 3(7) + 5 = 26; 7 \text{ ft} \times 26 \text{ ft}$

39. if the expression $b^2 - 4ac$ equals zero

40. $0 = -16t^2 + 5t + 50; a = -16, b = 5, c = 50; t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-5 \pm \sqrt{5^2 - 4(-16)(50)}}{2(-16)} = \frac{-5 \pm \sqrt{3225}}{-32}; t = \frac{-5 + \sqrt{3225}}{-32} \approx -1.6 \text{ or } t = \frac{-5 - \sqrt{3225}}{-32} \approx 1.9; \text{ about } 1.9 \text{ s}$

41a. Check students' work.

41b. $2025 - 1900 = 125; P = 0.0089(125)^2 + 1.1149(125) + 78.4491 \approx 356.9; \text{ about } 356.9 \text{ million}$

41c. $300 = 0.0089t^2 + 1.1149t + 78.4491; 0.0089t^2 + 1.1149t - 221.5509; t = \frac{-1.1149 \pm \sqrt{1.1149^2 - 4(0.0089)(-221.5509)}}{2(0.0089)}$

$t \approx 107 \text{ or } t \approx -232; \text{ use } t \approx 107; 1900 + 107 = 2007$

42a. $s = \frac{-b + \sqrt{b^2 - 4ac}}{2a} + \frac{-b - \sqrt{b^2 - 4ac}}{2a} = \frac{-b + \sqrt{b^2 - 4ac} - b - \sqrt{b^2 - 4ac}}{2a} = \frac{-2b}{2a} = -\frac{b}{a}; s = -\frac{b}{a}$

42b. $x - 8 = -\frac{3}{2}; x = 6.5$

43a. $38,100 \text{ tons} \cdot \frac{2000 \text{ pounds}}{1 \text{ ton}} = 76,200,000 \text{ pounds} = 7.62 \times 10^7 \text{ pounds}$

43b. $38,100 \text{ tons} - 5100 \text{ tons} = 33,000 \text{ tons} = 3.3 \times 10^4 \text{ tons}$

43c. $0 = -16t^2 + 0t + 630; 16t^2 = 630; t^2 = \frac{630}{16}; t = \pm\sqrt{\frac{630}{16}} = \pm 6.27; \text{ about } 6.27 \text{ s}$

44. $\frac{9 \pm \sqrt{(-9)^2 - 4(5)(-7)}}{2(5)}; a = 5, b = -9, c = -7; 5x^2 - 9x - 7 = 0, \text{ or } 5x^2 - 9x = 7; D$

45. $0 = -16t^2 + 0t + 630; 16t^2 = 630; t^2 = \frac{630}{16}; t = \pm\sqrt{\frac{630}{16}} = \pm 6.27; \text{ about } 6.27 \text{ s}$

46. $15x^2 - 59x - 112; a = 15, b = -59, c = -112; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-59) \pm \sqrt{(-59)^2 - 4(15)(-112)}}{2(15)} =$

$$\frac{59 \pm \sqrt{10,201}}{30} = \frac{59 \pm 101}{30}; x = \frac{59 + 101}{30} \approx 5.3 \text{ or } x =$$

$$\frac{59 - 101}{30} = -1.4; \text{F}$$

$$46. [2] 6x^2 - 40 = 11x; 6x^2 - 11x - 40 = 0; x = \frac{11 \pm \sqrt{(-11)^2 - 4(6)(-40)}}{2(6)}; x \approx$$

1.8 or $x = 3.7$ [1] correct substitution into quadratic formula, with one calculation error

$$47. d^2 - 10d + 13 = 0; d^2 - 10d + 25 = -13 + 25; (d - 5)^2 = 12;$$

$$d - 5 = \pm\sqrt{12} \approx \pm 3.46; d - 5 \approx 3.46 \text{ or } d - 5 \approx -3.46;$$

$$d = 8.46 \text{ or } d \approx 1.54$$

$$48. z^2 + 3z = -2; z^2 + 3z + \frac{9}{4} =$$

$$-2 + \frac{9}{4}(z + \frac{3}{2})^2 = \frac{1}{4}; z + \frac{3}{2} = \pm\sqrt{\frac{1}{4}} = \pm\frac{1}{2};$$

$$z + \frac{3}{2} = \frac{1}{2} \text{ or } z + \frac{3}{2} = -\frac{1}{2}; z = -1 \text{ or } z = -2$$

$$49. 3x^2 + 18x - 1 = 0; x^2 + 6x - \frac{1}{3} = 0; x^2 + 6x = \frac{1}{3};$$

$$x^2 + 6x + 9 = \frac{1}{3} + 9; (x + 3)^2 = \frac{28}{3}; x + 3 = \pm\sqrt{\frac{28}{3}} \approx$$

$$\pm 3.06; x + 3 \approx 3.06 \text{ or } x + 3 \approx -3.06; x = 0.06 \text{ or }$$

$$x = -6.06$$

$$50. 2c^2 + 11c + 15; 2(15) = 30; \text{factors with product 30 and sum 11: } 5 \text{ and } 6; 2c^2 + 11c + 15 =$$

$$2c^2 + (6 + 5)c + 15 = 2c^2 + 6c + 5c + 15 =$$

$$2c(c + 3) + 5(c + 3) = (2c + 5)(c + 3)$$

$$51. 3z^2 + 10z - 8; 3(-8) = -24; \text{factors with product } -24 \text{ and sum 10: }$$

$$12 \text{ and } -2; 3z^2 + 10z - 8 = 3z^2 + (12 - 2)z - 8 =$$

$$3z^2 + 12z - 2z - 8 = 3z(z + 4) - 2(z + 4) =$$

$$(3z - 2)(z + 4)$$

$$52. 5n^2 - 33n - 14; 5(-14) = -70; \text{factors with product } -70 \text{ and sum } -33: -35 \text{ and } 2;$$

$$5n^2 - 33n - 14 = 5n^2 + (-35 + 2)n - 14 =$$

$$5n^2 - 35n + 2n - 14 = 5n(n - 7) + 2(n - 7) =$$

$$(5n + 2)(n - 7)$$

$$53. 12v^2 + 32v - 35; 12(-35) = -420; \text{factors with product } -420 \text{ and sum } 32: 42 \text{ and } -10;$$

$$12v^2 + 32v - 35 = 12v^2 + (-10 + 42)v - 35 =$$

$$12v^2 - 10v + 42v - 35 = 2v(6v - 5) + 7(6v - 5) =$$

$$(6v - 5)(2v + 7)$$

$$54. 6x^2 - 13x + 5; 6(5) = 30; \text{factors with product } 30 \text{ and sum } -13: -3 \text{ and } -10;$$

$$6x^2 - 13x + 5 = 6x^2 + (-3 - 10)x + 5 =$$

$$6x^2 - 3x - 10x + 5 = 3x(2x - 1) - 5(2x - 1) =$$

$$(2x - 1)(3x - 5)$$

$$55. 15t^2 + 19t + 6; 15(6) = 90; \text{factors with product } 90 \text{ and sum } 19: 10 \text{ and } 9; 15t^2 + 19t + 6 =$$

$$15t^2 + (10 + 9)t + 6 = 15t^2 + 10t + 9t + 6 =$$

$$5t(3t + 2) + 3(3t + 2) = (5t + 3)(3t + 2)$$

$$3x^2 - 4x - 7 = 0; a = 3, b = -4, c = -7; b^2 - 4ac = (-4)^2 - 4(3)(-7) = 16 + 84 = 100 > 0; 2 \text{ solutions}$$

$$1c. 5x^2 + 8 = 2x; 5x^2 - 2x + 8 = 0; a = 5, b = -2, c = 8;$$

$$b^2 - 4ac = (-2)^2 - 4(5)(8) = 4 - 160 = -156 < 0; 0 \text{ solutions}$$

$$2. 20 = -16t^2 + 32t + 5; 0 = -16t^2 + 32t - 15; b^2 - 4ac = 32^2 - 4(-16)(-15) = 1024 - 960 = 64 > 0; \text{yes}$$

Exercises 1. The graph has 2 x -intercepts, so the equation has 2 solutions, and the discriminant is positive;

A. 2. The graph has no x -intercepts, so the equation has no solutions, and the discriminant is negative; C.

3. The graph has 1 x -intercept, so the equation has 1 solution, and the discriminant is zero; B.

$$4. x^2 - 3x + 4 = 0; b^2 - 4ac = (-3)^2 - 4(1)(4) = 9 - 16 = -7 < 0; 0 \text{ solutions}$$

$$5. x^2 - 6x + 9 = 0; b^2 - 4ac = (-6)^2 - 4(1)(9) = 36 - 36 = 0; 1 \text{ solution}$$

$$6. x^2 + 4x - 2 = 0; b^2 - 4ac = 4^2 - 4(1)(-2) = 16 + 8 = 24 > 0; 2 \text{ solutions}$$

$$7. x^2 - 1 = 0; b^2 - 4ac = 0^2 - 4(1)(-1) = 0 + 4 = 4 > 0; 2 \text{ solutions}$$

$$8. x^2 - 2x - 3 = 0; b^2 - 4ac = (-2)^2 - 4(1)(-3) = 4 + 12 = 16 > 0; 2 \text{ solutions}$$

$$9. x^2 + x = 0; b^2 - 4ac = 1^2 - 4(1)(0) = 1 - 0 = 1 > 0; 2 \text{ solutions}$$

$$10. 2x^2 - 3x + 4 = 0; b^2 - 4ac = (-3)^2 - 4(2)(4) = 9 - 32 = -23 < 0; 0 \text{ solutions}$$

$$11. 0 = x^2 - 6x + 5; b^2 - 4ac = (-6)^2 - 4(1)(5) = 36 - 20 = 16 > 0; 2 \text{ solutions}$$

$$12. x^2 - 7x + 6 = 0; b^2 - 4ac = (-7)^2 - 4(1)(6) = 49 - 24 = 25 > 0; 2 \text{ solutions}$$

$$13. x^2 + 2x + 1 = 0; b^2 - 4ac = 2^2 - 4(1)(1) = 4 - 4 = 0; 1 \text{ solution}$$

$$14. 0 = 2x^2 + 4x - 3; b^2 - 4ac = 4^2 - 4(2)(-3) = 16 + 24 = 40 > 0; 2 \text{ solutions}$$

$$15. 0 = x^2 + 2x + 9; b^2 - 4ac = 2^2 - 4(1)(9) = 4 - 36 = -32 < 0; 0 \text{ solutions}$$

$$16. 280 = (18 - x)(15 + x); 280 = 270 + 3x - x^2; x^2 - 3x + 10 = 0; b^2 - 4ac = (-3)^2 - 4(1)(10) = 9 - 40 = -31 < 0; \text{none}$$

$$17. 7000 = 5400 + 300n - 50n^2; 50n^2 - 300n + 1600 = 0; b^2 - 4ac = (-300)^2 - 4(50)(1600) = 90,000 - 320,000 =$$

$$-230,000 < 0; \text{No, because the discriminant is negative.}$$

$$18a. 16 = -16t^2 + 35t; 16t^2 - 35t + 16 = 0; b^2 - 4ac = (-35)^2 - 4(16)(16) = 1225 - 1024 = 201 > 0; \text{yes}$$

$$18b. 20 = -16t^2 + 35t; 16t^2 - 35t + 20 = 0; b^2 - 4ac = (-35)^2 - 4(16)(20) = 1225 - 1280 = -55 < 0; \text{no}$$

$$18c. 30 = -16t^2 + 35t; 16t^2 - 35t + 30 = 0; b^2 - 4ac = (-35)^2 - 4(16)(30) = 1225 - 1920 = -695 < 0; \text{no}$$

$$18d. 35 = -16t^2 + 35t; 16t^2 - 35t + 35 = 0; b^2 - 4ac = (-35)^2 - 4(16)(35) = 1225 - 2240 = -1015 < 0; \text{no}$$

$$19. 2x^2 + 4x + 15 = 0; b^2 - 4ac = 4^2 - 4(2)(15) = 16 - 120 = -104 < 0; 0 \text{ solutions, so 0 } x\text{-intercepts}$$

$$20. 4x^2 + 5x + 2 = 0; b^2 - 4ac = 5^2 - 4(4)(2) = 25 - 32 = -7 < 0; 0 \text{ solutions, so 0 } x\text{-intercepts}$$

$$21. x^2 - 8x + 12 = 0; b^2 - 4ac = (-8)^2 - 4(1)(12) = 64 - 48 = 16 > 0; 2 \text{ solutions, so 2 } x\text{-intercepts}$$

$$22. \frac{1}{2}x^2 + 4x - 7 = 0; b^2 - 4ac = 4^2 - 4\left(\frac{1}{2}\right)(-7) = 16 + 14 = 30 > 0; 2 \text{ solutions, so 2 } x\text{-intercepts}$$

$$23. 0.25x^2 - 1.2x + 3.2 = 0; b^2 - 4ac = (-1.2)^2 - 4(0.25)(3.2) = 1.44 - 3.2 = -1.76 < 0;$$

$$0 \text{ solutions, so 0 } x\text{-intercepts}$$

$$24. 5x^2 - 4.7x - 3.5 = 22.09 + 70 = b^2 - 4ac = (-4.7)^2 - 4(5)(-3.5) = 22.09 + 70 = 92.09 > 0; 2 \text{ solutions, so 2 } x\text{-intercepts}$$

$$25a. S = p(54 - 0.75p); S = 54p - 0.75p^2; S = -0.75p^2 + 54p$$

READING MATH

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$$a. 4x^2 - 8x - 45 = 0 \quad b. a = 4, b = -8, c = -45$$

$$c. x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-8) \pm \sqrt{(-8)^2 - 4(4)(-45)}}{2(4)} =$$

$$\frac{8 \pm \sqrt{784}}{8} = \frac{8 \pm 28}{8}, x = \frac{8 + 28}{8} = 4.5 \text{ or } x = \frac{8 - 28}{8} = -2.5$$

10-8 Using the Discriminant

pages 554–558

Check Skills You'll Need For complete solutions see Daily Skills Check and Lesson Quiz Transparencies or Presentation Pro CD-ROM.

$$1. -80 \quad 2. 72 \quad 3. -283 \quad 4. 2.18, 0.15 \quad 5. 0.39, -0.64 \quad 6. 7, 5$$

Check Understanding 1a. $x^2 = 2x - 3; x^2 - 2x + 3 = 0; a = 1, b = -2, c = 3; b^2 - 4ac = (-2)^2 - 4(1)(3) =$

$$4 - 12 = -8 < 0; 0 \text{ solutions}$$

$$1b. 3x^2 - 4x = 7; 3x^2 - 4x - 7 = 0; b^2 - 4ac =$$

25b. $1,000,000 = -0.75p^2 + 54p$;

$0.75p^2 - 54p + 1,000,000 = 0$; $b^2 - 4ac =$

$(-54)^2 - 4(0.75)(1,000,000) = 2916 - 3,000,000 =$

$-2,997,084 < 0$; no **25c.** $-\frac{b}{2a} = -\frac{54}{2(-0.75)} = 36$; \$36

25d. If a product is too expensive, fewer people will buy it. **26.** $x^2 + 4x + k = 0$; $b^2 - 4ac = 4^2 - 4(1)(k) =$

$16 - 4k$ **26a.** $16 - 4k < 0$; $-4k < -16$; $k > 4$

26b. $16 - 4k = 0$; $4k = 16$; $k = 4$ **26c.** $16 - 4k > 0$;

$-4k > -16$; $k < 4$ **27a.** cell B2: $x^2 + bx + 1 = 0$;

$b^2 - 4ac = b^2 - 4(1)(1) = b^2 - 4$; A2 \wedge 2 - 4;

cell C2: $x^2 + bx + 2 = 0$; $b^2 - 4ac = b^2 - 4(1)(2) =$

$b^2 - 8$; A2 \wedge 2 - 8 **27b.** $x^2 + bx + 1 = 0$; $b^2 - 4ac =$

$b^2 - 4(1)(1) = b^2 - 4$; for no solutions, $b^2 - 4 < 0$;

$b^2 < 4$; $|b| < 2$ **28.** $0 = 3t^2 - 2t + 450$; $b^2 - 4ac =$

$(-2)^2 - 4(3)(450) = 4 - 5400 = -5396 < 0$; no

29. $2x^2 + 5x - 1 = 0$; $b^2 - 4ac = 5^2 - 4(2)(-1) =$

$25 + 8 = 33$; note $25 - 8 = 17$; answers may vary.

Sample: Kenji used $c = 1$ instead of $c = -1$.

30a. $x^2 - 6x + 5 = 0$; discriminant: $b^2 - 4ac =$

$(-6)^2 - 4(1)(5) = 36 - 20 = 16$; solutions:

$(x - 5)(x - 1) = 0$; $x - 5 = 0$ or $x - 1 = 0$; $x = 5$ or

$x = 1$ **30b.** $x^2 + x - 20 = 0$; discriminant: $b^2 - 4ac =$

$1^2 - 4(1)(-20) = 1 + 80 = 81$; solutions: $(x - 4)(x + 5) =$

0 ; $x - 4 = 0$ or $x + 5 = 0$; $x = 4$ or $x = -5$

30c. $2x^2 - 7x - 3 = 0$; discriminant: $b^2 - 4ac =$

$(-7)^2 - 4(2)(-3) = 49 + 24 = 73$; solutions:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-7) \pm \sqrt{73}}{2(2)} = \frac{7 \pm \sqrt{73}}{4},$$

$$x = \frac{7 + \sqrt{73}}{4} \approx 3.89 \text{ or } x = \frac{7 - \sqrt{73}}{4} \approx -0.39$$

30d. The solutions are rational, because the square root of a discriminant that is a perfect square is a positive integer. **31.** $x^2 - 2x + 5 = 0$; $b^2 - 4ac =$

$(-2)^2 - 4(1)(5) = 4 - 20 = -16 < 0$; no

32. $2x^2 - 4x + 3 = 0$; $b^2 - 4ac = (-4)^2 - 4(2)(3) =$

$16 - 24 = -8 < 0$; no **33.** $4x^2 + x - 5 = 0$; $b^2 - 4ac =$

$1^2 - 4(4)(-5) = 1 + 80 = 81 > 0$; yes; $(4x + 5)(x - 1) = 0$; $4x + 5 = 0$ or $x - 1 = 0$; $4x = -5$ or $x = 1$;

$x = -1.25$ or $x = 1$ **34.** $-3x^2 - x + 2 = 0$; $b^2 - 4ac =$

$(-1)^2 - 4(-3)(2) = 1 + 24 = 25 > 0$; yes;

$(-3x + 2)(x + 1) = 0$; $-3x + 2 = 0$ or $x + 1 = 0$;

$3x = 2$ or $x = -1$; $x = \frac{2}{3}$ or $x = -1$ **35.** $x^2 - 5x + 7 = 0$;

$b^2 - 4ac = (-5)^2 - 4(1)(7) = 25 - 28 = -3 < 0$; no

36. $2x^2 - 3x - 5 = 0$; $b^2 - 4ac = (-3)^2 - 4(2)(-5) =$

$9 + 40 = 49 > 0$; yes; $(2x - 5)(x + 1) = 0$; $2x - 5 = 0$ or

$x + 1 = 0$; $2x = 5$ or $x = -1$; $x = 2.5$ or $x = -1$

37. Answers may vary. Sample: Use values for a , b , and c such that the discriminant is positive.

38–40. $ax^2 + bx + c = 0$ will have two solutions whenever $b^2 - 4ac > 0$, or $b^2 > 4ac$. **38.** $b^2 < 4ac$, so it is never true that $b^2 > 4ac$. **39.** $b^2 = 0$, so it is sometimes true that $b^2 > 4ac$. **40.** $ac < 0$, so $4ac < 0$, and it is always true that $b^2 > 4ac$ because $b^2 > 0$. **41.** The equation has 2 solutions; since the parabola crosses the x -axis once, it must cross it again. **42.** $y = 2x^2 + 8x + 10$ has a vertex closer to the x -axis; its discriminant is closer to zero.

43. $b^2 - 4ac = 7^2 - 4(1)(-4) = 49 + 16 = 65$; C

44. F. $3x^2 - 5x + 1 = 0$; $b^2 - 4ac = (-5)^2 - 4(3)(1) =$

$25 - 12 = 13 > 0$; 2 solutions. G. $3x^2 - 5x + 4 = 0$;

$b^2 - 4ac = (-5)^2 - 4(3)(4) = 25 - 48 = -23 < 0$, no solutions. H. $-3x^2 - 11x + 4 = 0$; $b^2 - 4ac =$

$(-11)^2 - 4(-3)(4) = 121 + 48 = 169 > 0$, 2 solutions. I. $-2x^2 - 3x + 1 = 0$; $b^2 - 4ac = (-3)^2 - 4(-2)(1) =$

$9 + 8 = 17 > 0$, 2 solutions. The answer is G.

45. A. $35 = 20x^2 - 15x + 47$; $20x^2 - 15x + 12 = 0$;

$b^2 - 4ac = (-15)^2 - 4(20)(12) = 225 - 960 =$

$-735 < 0$, no solutions. B. $15x + 7 = 0$; $15x = -7$;

$x = -\frac{7}{15}$, 1 solution; the answer is B.

46. A. $ax^2 + 5x - 3 = 0$; $b^2 - 4ac = 5^2 - 4a(-3) =$

$25 + 12a$. B. $5x^2 + bx - 3 = 0$; $b^2 - 4ac =$

$b^2 - 4(5)(-3) = b^2 + 60$; the answer is D.

47. A. $4x^2 - x - 6 = 0$; $b^2 - 4ac = (-1)^2 - 4(4)(-6) =$

$1 + 96 = 97$. B. $4x^2 - x + 6 = 0$; $b^2 - 4ac =$

$(-1)^2 - 4(4)(6) = 1 - 96 = -95$; the answer is A.

48. [2] $x(25 - x) = 136$; $x^2 - 25x + 136 = 0$; $x =$

$$\frac{-(-25) \pm \sqrt{(-25)^2 - 4(1)(136)}}{2(1)} = \frac{25 \pm 9}{2} = 17 \text{ or } 8;$$

yes, 17 cm by 8 cm [1] no work shown or appropriate methods with one computational error

49. $4x^2 + 4x - 3 = 0$; $a = 4$, $b = 4$, $c = -3$;

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-4 \pm \sqrt{4^2 - 4(4)(-3)}}{2(4)} =$$

$$\frac{-4 \pm \sqrt{64}}{8} = \frac{-4 \pm 8}{8}; x = \frac{-4 + 8}{8} = 0.5 \text{ or } x = \frac{-4 - 8}{8} =$$

50. $x^2 + 2x - 7 = 0$; $a = 1$, $b = 2$, $c = -7$; $x =$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2 \pm \sqrt{2^2 - 4(1)(-7)}}{2(1)} = \frac{-2 \pm \sqrt{32}}{2},$$

$$x = \frac{-2 + \sqrt{32}}{2} \approx 1.83 \text{ or } x = \frac{-2 - \sqrt{32}}{2} \approx -3.83$$

51. $6x^2 - 2x - 1 = 0$; $a = 6$, $b = -2$, $c = -1$; $x =$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-2) \pm \sqrt{(-2)^2 - 4(6)(-1)}}{2(6)} =$$

$$\frac{2 \pm \sqrt{28}}{12}; x = \frac{2 + \sqrt{28}}{12} \approx 0.61 \text{ or } x = \frac{2 - \sqrt{28}}{12} \approx -0.27$$

52. $x^2 + x = 5$; $x^2 + x - 5 = 0$; $a = 1$, $b = 1$, $c = -5$; $x =$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-1 \pm \sqrt{1^2 - 4(1)(-5)}}{2(1)} = \frac{-1 \pm \sqrt{21}}{2},$$

$$x = \frac{-1 + \sqrt{21}}{2} \approx 1.79 \text{ or } x = \frac{-1 - \sqrt{21}}{2} \approx -2.79$$

53. $3x^2 - 8x + 1 = 0$; $a = 3$, $b = -8$, $c = 1$; $x =$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-8) \pm \sqrt{(-8)^2 - 4(3)(1)}}{2(3)} = \frac{8 \pm \sqrt{52}}{6},$$

$$x = \frac{8 + \sqrt{52}}{6} \approx 2.54 \text{ or } x = \frac{8 - \sqrt{52}}{6} \approx 0.13$$

54. $2x^2 - 7x = -6$; $2x^2 - 7x + 6 = 0$; $a = 2$, $b = -7$, $c =$

$$6$$
; $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-7) \pm \sqrt{(-7)^2 - 4(2)(6)}}{2(2)} =$

$$\frac{7 \pm \sqrt{1}}{4} = \frac{7 \pm 1}{4}; x = \frac{7 + 1}{4} = 2 \text{ or } x = \frac{7 - 1}{4} = 1.5$$

55. $y = \$1000 \cdot 1.0075^{12} \approx \1093.81 **56.** $y =$

$$\$200 \cdot 1.01125^{40} \approx \$312.88$$
 57. $y = \$5000 \cdot 1.00416^{48} \approx$

$$\$6104.48$$
 58. $9 - 5 = 4$, $13 - 9 = 4$; arithmetic

59. $-16 - (-11) = -5$, $-21 - (-16) = -5$; arithmetic

60. $20 \div 10 = 2$, $40 \div 20 = 2$; geometric

61. $6 - 3 = 3$, $9 - 6 = 3$; arithmetic

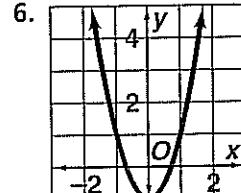
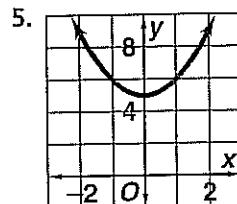
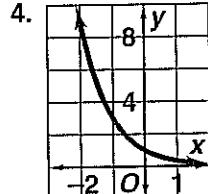
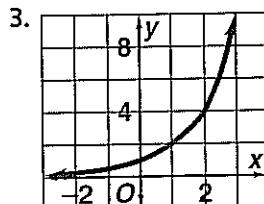
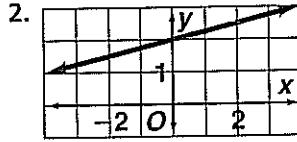
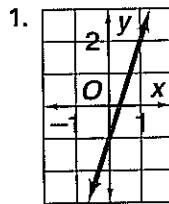
CHECKPOINT QUIZ 2

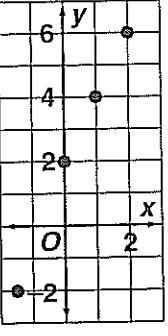
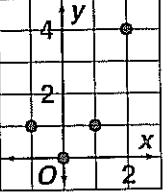
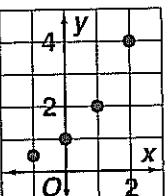
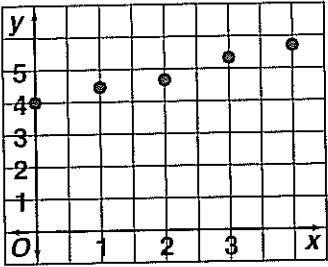
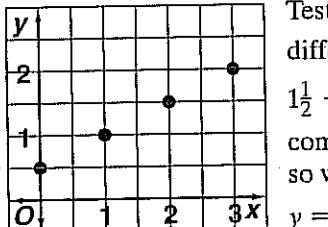
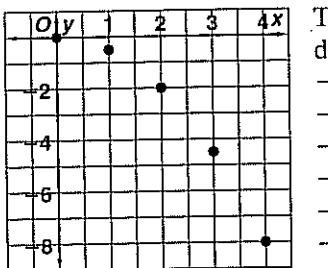
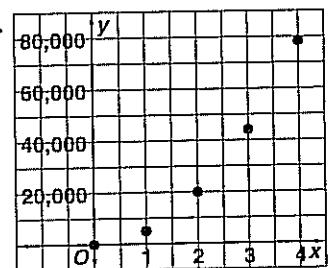
page 558

1. $(x + 3)(x - 7) = 0; x + 3 = 0 \text{ or } x - 7 = 0; x = -3$
 or $x = 7$ 2. $x^2 + 12x + 27 = 0; (x + 3)(x + 9) = 0;$
 $x + 3 = 0 \text{ or } x + 9 = 0; x = -3 \text{ or } x = -9$
 3. $x^2 - 5x = 50; x^2 - 5x - 50 = 0; (x + 5)(x - 10) = 0;$
 $x + 5 = 0 \text{ or } x - 10 = 0; x = -5 \text{ or } x = 10$
 4. $x^2 + 2x - 1 = 0; a = 1, b = 2, c = -1; x =$
 $\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-2 \pm \sqrt{2^2 - 4(1)(-1)}}{2(1)} = \frac{-2 \pm \sqrt{8}}{2},$
 $x = \frac{-2 + \sqrt{8}}{2} \approx 0.4 \text{ or } x = \frac{-2 - \sqrt{8}}{2} \approx -2.4$
 5. $x^2 - 5x - 4 = 0; a = 1, b = -5, c = -4; x =$
 $\frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{(-5) \pm \sqrt{(-5)^2 - 4(1)(-4)}}{2(1)} =$
 $\frac{5 \pm \sqrt{41}}{2}; x = \frac{5 + \sqrt{41}}{2} \approx 5.7 \text{ or } x = \frac{5 - \sqrt{41}}{2} \approx -0.7$
 6. $x^2 - 8x - 33 = 0; (x - 11)(x + 3) = 0; x - 11 = 0 \text{ or}$
 $x + 3 = 0; x = 11 \text{ or } x = -3$ 7. $4x^2 - x - 3 = 0;$
 $(4x + 3)(x - 1) = 0; 4x + 3 = 0 \text{ or } x - 1 = 0; 4x = -3$
 or $x = 1; x = -\frac{3}{4} \text{ or } x = 1$ 8. $4x^2 - x + 3 = 0; a = 4,$
 $b = -1, c = 3; x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} =$
 $\frac{(-1) \pm \sqrt{(-1)^2 - 4(4)(3)}}{2(4)} = \frac{1 \pm \sqrt{-47}}{8},$
 discriminant < 0, no solution 9. $2x^2 - 3x + 1 = 0;$
 $(2x - 1)(x - 1) = 0; 2x - 1 = 0 \text{ or } x - 1 = 0; 2x = 1$
 or $x = 1; x = 0.5 \text{ or } x = 1$ 10. $4x^2 - 3x + 5 = 0;$
 $b^2 - 4ac = (-3)^2 - 4(4)(5) = 9 - 80 = -71 < 0;$
 0 solutions

10.9 Choosing a Linear, Quadratic, or Exponential Model pages 559–566

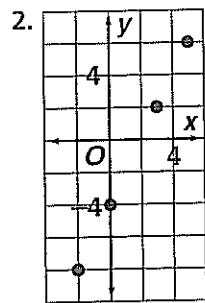
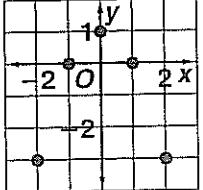
Check Skills You'll Need For complete solutions see Daily Skills Check and Lesson Quiz Transparencies or Presentation Pro CD-ROM.


Check Understanding

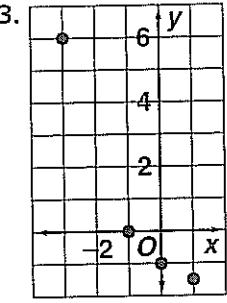
- 1a. linear 
- 1b. quadratic 
- 1c. exponential 
- 2a. Test for a common ratio: $4.4 \div 4 = 1.1$, $4.84 \div 4.4 = 1.1$, $5.324 \div 4.84 = 1.1$, $5.8564 \div 5.324 = 1.1$; common ratio is 1.1, so write an exponential model: $y = 4 \cdot 1.1^x$. 
- 2b. Test for a common difference: $1 - \frac{1}{2} = \frac{1}{2}$, $1\frac{1}{2} - 1 = \frac{1}{2}$, $2 - 1\frac{1}{2} = \frac{1}{2}$; common difference is $\frac{1}{2}$, so write a linear model: $y = \frac{1}{2}x + \frac{1}{2}$. 
- 2c. Test for a common second difference: $-0.5 - 0 = -0.5$, $-2 - (-0.5) = -1.5$, $-4.5 - (-2) = -2.5$, $-8 - (-4.5) = -3.5$, and $-1.5 - (-0.5) = -1$, $-2.5 - (-1.5) = -1$, $-3.5 - (-2.5) = -1$; common second difference is -1 , so write a quadratic model: $y = ax^2$, $-2 = a \cdot 2^2$, $a = -\frac{1}{2}$, $y = -\frac{1}{2}x^2$. 
- 3a. Test for a common second difference: $5000 - 0 = 5000$, $20,000 - 5000 = 15,000$, $44,000 - 20,000 = 24,000$, $79,000 - 44,000 = 35,000$, and $15,000 - 5000 = 10,000$, $24,000 - 15,000 = 9,000$, $35,000 - 24,000 = 11,000$; common second difference is about 10,000, so the function is quadratic. 

3b. $y = ax^2$; $20,000 = a \cdot 2^2$, $a = 5000$; $y = 5000x^2$

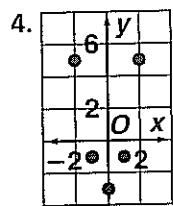
Exercises 1. quadratic



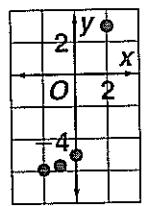
linear



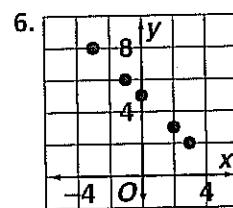
exponential



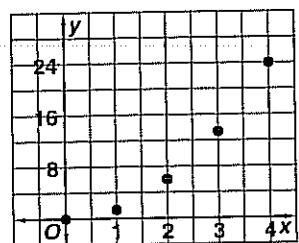
quadratic



exponential

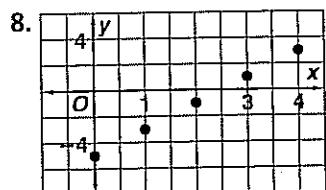


linear



Test for a common second difference: $1.5 - 0 = 1.5$, $6 - 1.5 = 4.5$, $13.5 - 6 = 7.5$, $24 - 13.5 = 10.5$, and $4.5 - 1.5 = 3$, $7.5 - 4.5 = 3$, $10.5 - 7.5 = 3$; common second difference is 3, so the function is quadratic.

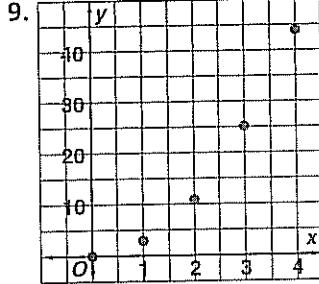
$$y = ax^2, 6 = a \cdot 2^2, a = 1.5; y = 1.5x^2$$



Test for a common difference:

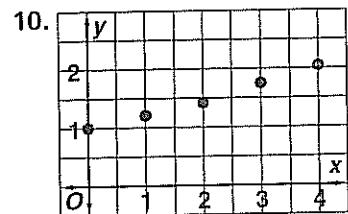
$$\begin{aligned} -3 - (-5) &= 2, \\ -1 - (-3) &= 2, \\ 1 - (-1) &= 2, \\ 3 - 1 &= 2; \end{aligned}$$

common difference is 2, so the function is linear. $y = 2x + 5$

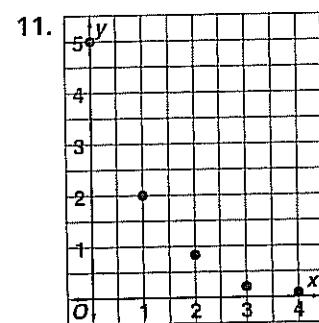


Test for a common second difference: $2.8 - 0 = 2.8$, $11.2 - 2.8 = 8.4$, $25.2 - 11.2 = 14$, $44.8 - 25.2 = 19.6$, and $8.4 - 2.8 = 5.6$, $14 - 8.4 = 5.6$, $19.6 - 14 = 5.6$; common second difference is 5.6, so the function is quadratic.

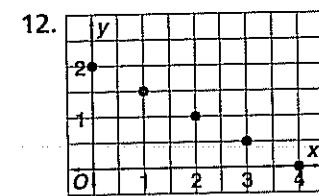
$$y = ax^2, 11.2 = a \cdot 2^2, a = \frac{11.2}{4} = 2.8; y = 2.8x^2$$



Test for a common ratio: $1.2 \div 1 = 1.2$, $1.44 \div 1.2 = 1.2$, $1.728 \div 1.44 = 1.2$, $2.0736 \div 1.728 = 1.2$; common ratio is 1.2, so the function is exponential. $y = 1 \cdot 1.2^x$

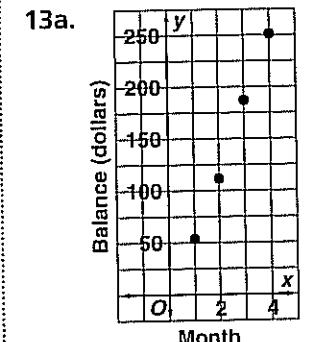


Test for a common ratio: $2 \div 5 = 0.4$, $0.8 \div 2 = 0.4$, $0.32 \div 0.8 = 0.4$, $0.128 \div 0.32 = 0.4$; common ratio is 0.4, so the function is exponential. $y = 5 \cdot 0.4^x$



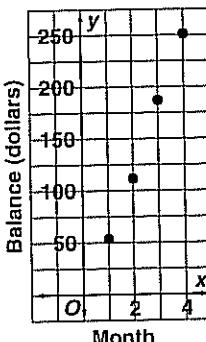
Test for a common difference: $1.5 - 2 = -0.5$, $1 - 1.5 = -0.5$, $0.5 - 1 = -0.5$, $0 - 0.5 = -0.5$; common difference is -0.5 , so the function is linear.

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



linear

- 13b. $123 - 58 = 65$,
 187 - 123 = 64,
 251 - 187 = 64; yes
 13c. 64 13d. $y = 64x - 5$



14a. The data appears exponential, so test for a common ratio: $14,500 \div 16,500 \approx 0.88$, $12,750 \div 14,500 \approx 0.88$, $11,200 \div 12,750 \approx 0.88$, $9900 \div 11,200 \approx 0.88$; common ratio is about 0.88, so the function is exponential.

$$14b. y = 16,500 \cdot 0.88^x$$

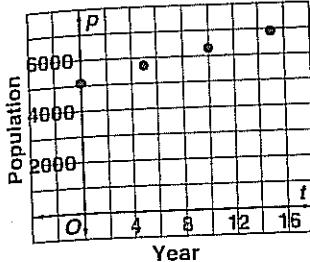
$$15a. 41 - 0 = 41, 164 - 41 = 123, 370 - 164 = 206$$

$$15b. 123 - 41 = 82, 206 - 123 = 83$$

$$15c. d = 41t^2$$

$$15d. d = 41 \cdot 2.5^2 = 256.25; 256.25 \text{ cm}$$

16a.



linear

- 16b. $5 - 0 = 5$,
 $10 - 5 = 5$, $15 - 10 = 5$; 5 years
 16c. differences of consecutive terms:
 $5700 - 5100 = 600$,
 $6300 - 5700 = 600$,
 $6900 - 6300 = 600$;
 possible common differences: $600 \div 5 = 120$, 120, 120

- 16d. $p = 120t + 5100$ 17a. $5 - 0 = 5$; 5 years
 17b. differences of consecutive terms: $4855 - 4457 = 398$, $5284 - 4855 = 429$, $5691 - 5284 = 407$,
 $6080 - 5691 = 389$; possible common differences:
 $398 \div 5 = 79.6$, $429 \div 5 = 85.8$, $407 \div 5 = 81.4$,
 $389 \div 5 = 77.8$ 17c. $(79.6 + 85.8 + 81.4 + 77.8) \div 4 = 81.15 \approx 81.2$ 17d. $p = 81.2t + 4457$ 17e. $2010 - 1980 = 30$; $p = 81.2(30) + 4457 = 6893$; 6893 million, or about 6.9 billion 18. Answers may vary. Sample: Linear data have a common first difference, quadratic data have a common second difference, and exponential data have a common ratio. 19. $y = 0.875x^2 - 0.435x + 1.515$
 20. $y = 1.987 \cdot 0.770^x$ 21. $y = 2.125x^2 - 4.145x + 2.955$
 22. $y = -0.336x^2 - 0.219x + 4.666$ 23. $y = -1.1x + 3.5$
 24. $y = 0.102 \cdot 2.582^x$

25ai.

x	y
1	-2
2	1) 3
3	6) 5) 2
4	13) 7) 2
5	22

25aii.

x	y
1	3
2	12) 9) 6
3	27) 21) 6
4	48) 27) 6
5	75

25aiii.

x	y
1	-1) 7
2	6) 15) 8
3	21) 23) 8
4	44) 31) 8
5	75

- 25b. The second common difference is twice the coefficient of x^2 . 25c. When second differences are the same, the data are quadratic. You can determine the coefficient of x^2 by dividing the second difference by 2.

26. Answers may vary. Sample:

x	y
0	5
2	13
4	29
6	53

- 27a. The data appear quadratic, so test for a common second difference: $2.2 - 0.5 = 1.7$, $4.9 - 2.2 = 2.7$, $8.7 - 4.9 = 3.8$, $13.6 - 8.7 = 4.9$, and $2.7 - 1.7 = 1$, $3.8 - 2.7 = 1.1$, $4.9 - 3.8 = 1.1$; common second difference is about 1.1, so the function is quadratic.

27b. $8.7 = a \cdot 0.8^2$, $a = \frac{8.7}{0.8^2} \approx 13.6$; $d = 13.6t^2$

- 27c. $d = 13.6 \cdot 2^2 = 54.4$; about 54.4 ft 28a. $y = ax^2 + bx + c$ with $(0, 4)$: $4 = a \cdot 0^2 + b \cdot 0 + c$, $4 = 0 + 0 + c$, $c = 4$ 28b. Answers may vary. Sample:

- ① $13 = a \cdot 1^2 + b \cdot 1 + 4$, or $a + b = 9$
 ② $26 = a \cdot 2^2 + b \cdot 2 + 4$, or $4a + 2b = 22$

28c. Multiply ① by 2 and subtract ②:

$$\begin{array}{r} 2a + 2b = 18 \\ - 4a + 2b = 22 \\ \hline -2a & = -4 \\ a & = 2 \end{array}$$

$a + b = 9$, $2 + b = 9$, $b = 7$; $a = 2$ and $b = 7$

- 28d. $y = ax^2 + bx + c$ with $a = 2$, $b = 7$, and $c = 4$: $y = 2x^2 + 7x + 4$ 28e. Answers may vary. Sample: Check

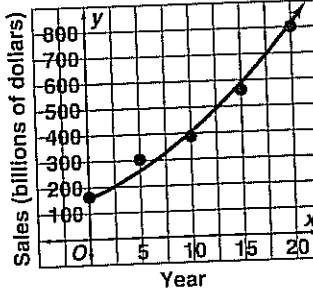
$$2x^2 + 7x + 4 \quad 28e. \text{Answers may vary. Sample: Check } (2, 26). 26 \stackrel{?}{=} 2(2^2) + 7(2) + 4; 26 \stackrel{?}{=} 8 + 14 + 4; 26 = 26 \checkmark$$

$$26 \checkmark \quad 29a. 303 \div 164 \approx 1.85, 388 \div 303 \approx 1.28, 562 \div 388 \approx 1.45, 802 \div 562 \approx 1.43 \quad 29b. 303 - 164 = 139, 388 - 303 = 85, 562 - 388 = 174, 802 - 562 = 240$$

$$29c. 85 - 139 = -54, 174 - 85 = 89, 240 - 174 = 66$$

- 29d. 1.85; the ratio is much larger than the other ratios.
 29e. 85; the difference is much smaller than the other differences.

29f.



30. The data appear linear, so test for a common difference: $4 - 2 = 2$, $6 - 4 = 2$, $8 - 6 = 2$, $10 - 8 = 2$; common difference is 2, so the data are linear with equation $y = 2x + 2$; B. 31. Test for a common ratio. F. $4 \div 16 = 0.25$, $2 \div 4 = 0.5$, $-2 \div 2 = -1$, $4 \div -2 = -2$, no common ratio. G. $-4 \div -7 \approx 0.57$, $-1 \div -4 = 0.25$, $2 \div -1 = -2$, $5 \div 2 = 2.5$, no common ratio.

- H. $3 \div 1 = 3$, $8 \div 3 = 2.6$, $14 \div 8 = 1.75$, close to a common ratio. I. $3 \div -4 = -0.75$, $8 \div 3 = 2.6$, $14 \div 8 = 1.75$, $12 \div 14 \approx 0.86$, no common ratio. The answer is H. 1.75, $12 \div 14 \approx 0.86$, no common ratio. The answer is H. 32. [2] $p = 33,500(1.014)^n$, $33,500(1.014)^{10} \approx 38,497$

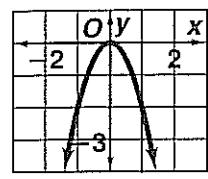
- [1] correct formula, inaccurate evaluation 33. [4]

- 33a. Test for a common difference: $41 - 43.5 = -2.5$, $38.5 - 41 = -2.5$, $36 - 38.5 = -2.5$, $33.5 - 36 = -2.5$,

- $31 - 33.5 = -2.5$; common difference is -2.5 , so the model is linear. **33b.** $d = -2.5n + 43.5$ **33c.** $0 = -2.5n + 43.5$; $2.5n = 43.5$; $n = 17.4$; 18 marbles
 [3] appropriate methods, but with one computational error [2] part (c) not answered [1] no work shown
34. $y = -x^2$; $b^2 - 4ac = 0^2 - 4(-1)(0) = 0 - 0 = 0$; 1 x -intercept **35.** $y = x^2 + 3x + 4$; $b^2 - 4ac = 3^2 - 4(1)(4) = 9 - 16 = -7 < 0$; 0 x -intercepts
36. $y = 4x^2 - 10x + 3$; $b^2 - 4ac = (-10)^2 - 4(4)(3) = 100 - 48 = 52 > 0$; 2 x -intercepts

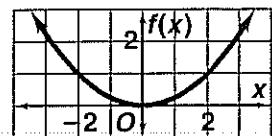
37.

x	$y = -2x^2$	(x, y)
0	$-2(0)^2 = 0$	(0, 0)
1	$-2(1)^2 = -2$	(1, -2)
2	$-2(2)^2 = -8$	(2, -8)

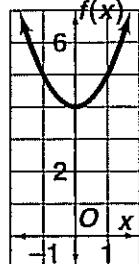


38.

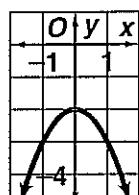
x	$f(x) = \frac{1}{4}x^2$	(x, y)
0	$\frac{1}{4}(0)^2 = 0$	(0, 0)
2	$\frac{1}{4}(2)^2 = 1$	(2, 1)
3	$\frac{1}{4}(3)^2 = 2.25$	(3, 2.25)



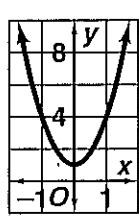
- 39.** $f(x) = x^2 + 4$; same as $f(x) = x^2$, but shifted up 4 units



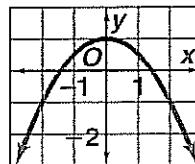
- 40.** $y = -x^2 - 2$; same as $y = -x^2$, but shifted down 2 units



- 41.** $y = 3x^2 + 1$; same as $y = 3x^2$, but shifted up 1 unit



- 42.**



- $y = -\frac{1}{2}x^2 + 1$; same as $y = -\frac{1}{2}x^2$, but shifted up 1 unit

43. $y = 2^x$ for $x = -3$: $y = 2^{-3} = \frac{1}{2^3} = \frac{1}{8} = 0.125$

44. $f(x) = -2^x$ for $x = 5$: $-2^5 = -32$

45. $g(t) = 2 \cdot 3^t$ for $t = -3$: $2 \cdot 3^{-3} = 2 \cdot \frac{1}{3^3} = \frac{2}{27}$

46. $f(t) = 10 \cdot 5^t$ for $t = 2$: $10 \cdot 5^2 = 10 \cdot 25 = 250$

47. $y = \left(\frac{1}{2}\right)^t$ for $t = -4$: $\left(\frac{1}{2}\right)^{-4} = \left(\frac{2}{1}\right)^4 = 2^4 = 16$

48. $y = 9 \cdot \left(\frac{3}{2}\right)^x$ for $x = 3$: $9 \cdot \left(\frac{3}{2}\right)^3 = 9 \cdot \frac{27}{8} = 30.375$

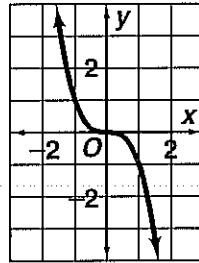
EXTENSION

page 567

1. Both graphs have the same shape, go through the origin, and lie in Quadrants I and III. The graph of $y = x^3$ is narrower than the graph of $y = \frac{1}{3}x^3$.

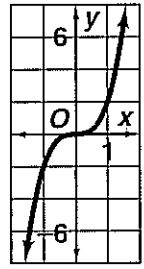
2ai.

x	$y = -x^3$	(x, y)
-2	$-(-2)^3 = 8$	(-2, 8)
-1	$-(-1)^3 = 1$	(-1, 1)
0	$-0^3 = 0$	(0, 0)
1	$-1^3 = -1$	(1, -1)
2	$-2^3 = -8$	(2, -8)



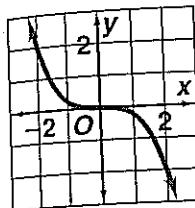
2aii.

x	$y = 2x^3$	(x, y)
-2	$2(-2)^3 = -16$	(-2, -16)
-1	$2(-1)^3 = -2$	(-1, -2)
0	$2(0)^3 = 0$	(0, 0)
1	$2(1)^3 = 2$	(1, 2)
2	$2(2)^3 = 16$	(2, 16)



2aiii.

x	$y = -\frac{1}{4}x^3$	(x, y)
-2	$-\frac{1}{4}(-2)^3 = 2$	(-2, 2)
-1	$-\frac{1}{4}(-1)^3 = \frac{1}{4}$	$(-1, \frac{1}{4})$
0	$-\frac{1}{4}(0)^3 = 0$	(0, 0)
1	$-\frac{1}{4}(1)^3 = -\frac{1}{4}$	$(1, -\frac{1}{4})$
2	$-\frac{1}{4}(2)^3 = -2$	(2, -2)

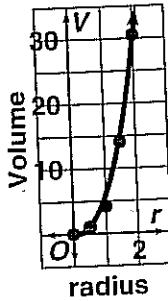


- 2b. The graphs with negative coefficients of x^3 are in Quadrants II and IV, and the graph with a positive coefficient of x^3 is in Quadrants I and III. All of the graphs go through the origin. 3. Yes; the sign of a changes which quadrants the graphs are in, and the larger $|a|$, the narrower the graph. 4a. no
4b. Yes; half of the graph is reflected over the y -axis and then over the x -axis.

5a.

r	$V = \frac{4}{3}\pi r^3$	(V, r)
0	$\frac{4}{3}\pi(0)^3 = 0$	(0, 0)
0.5	$\frac{4}{3}\pi(0.5)^3 \approx 0.5$	(0.5, 0.5)
1	$\frac{4}{3}\pi(1)^3 \approx 4.2$	(1, 4.2)
1.5	$\frac{4}{3}\pi(1.5)^3 \approx 14.1$	(1.5, 14.1)
2	$\frac{4}{3}\pi(2)^3 \approx 33.5$	(2, 33.5)

- 5b. when $V = 10$, $r \approx 1.3$; about 1.3 ft



TEST-TAKING STRATEGIES

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- 1a. $x^2 + 4x - n^2 = 0$; $b^2 - 4ac = 4^2 - 4(1)(-n^2) = 16 + 4n^2$ 1b. The smallest value of n^2 is 0, $16 + 0 > 0$.
1c. Since the discriminant is always positive, the equation has two solutions; C. 2. $x^2 + 2xy + y^2 = 0$; $(x + y)^2 = 0$; $x + y = 0$; $x = -y$; $\frac{x}{y} = -1$; C

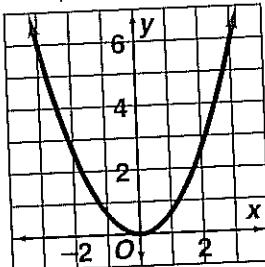
CHAPTER REVIEW

pages 569-571

1. The U-shaped graph of a quadratic function is a parabola. 2. If the quadratic expression $ax^2 + bx + c$ cannot be factored, one good way to solve the equation $ax^2 + bx + c = 0$ is to use completing the square.
3. If $a^2 = b$ and $a > 0$, then a is the principal square root of b . 4. The vertex of a parabola is the point at which the parabola intersects the axis of symmetry.
5. The discriminant can be used to determine the number of solutions of a quadratic equation.
6-9. Answers may vary. Samples are given.
6. $y = -2x^2$ 7. $y = 2x^2$ 8. $y = x^2$ 9. $y = \frac{1}{2}x^2$

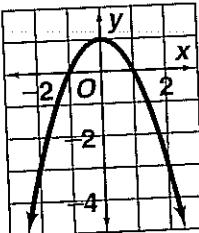
10.

x	$y = \frac{2}{3}x^2$	(x, y)
0	$\frac{2}{3}(0)^2 = 0$	(0, 0)
1	$\frac{2}{3}(1)^2 = \frac{2}{3}$	$(1, \frac{2}{3})$
2	$\frac{2}{3}(2)^2 = 2\frac{2}{3}$	$(2, 2\frac{2}{3})$
3	$\frac{2}{3}(3)^2 = 6$	(3, 6)



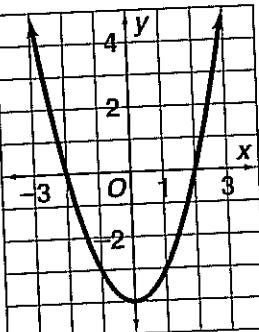
11.

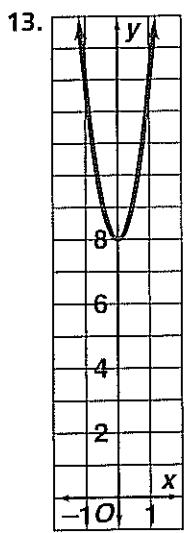
- $y = -x^2 + 1$; same as $y = -x^2$, but shifted up 1 unit



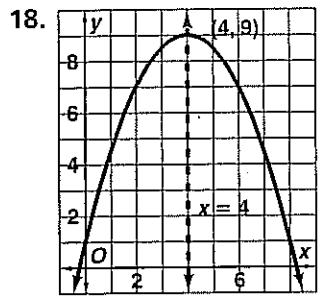
12.

- $y = x^2 - 4$; same as $y = x^2$, but shifted down 4 units



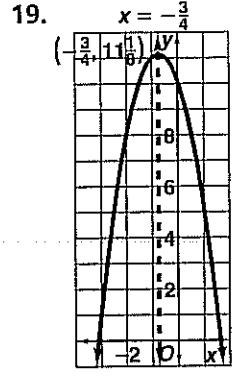


$y = 5x^2 + 8$; same as $y = 5x^2$, but shifted up 8 units

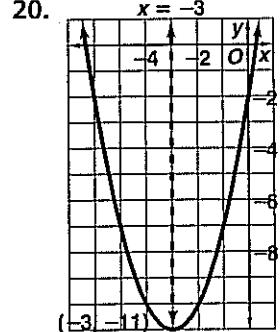


$$y = -\frac{1}{2}x^2 + 4x + 1; \text{ axis of symmetry: } x = -\frac{b}{2a} = -\frac{4}{2(-\frac{1}{2})} = 4;$$

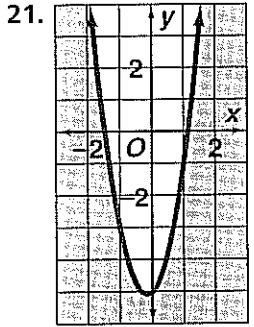
$$\text{y-coordinate of vertex: } y = -\frac{1}{2}(4)^2 + 4(4) + 1 = 9; \text{ vertex } (4, 9); \text{ points } (0, 1), (2, 7)$$



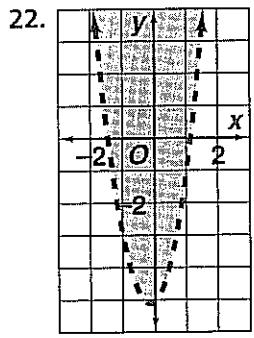
$$y = -2x^2 - 3x + 10; \text{ axis of symmetry: } x = -\frac{b}{2a} = -\frac{-3}{2(-2)} = -\frac{3}{4}; \text{ y-coordinate of vertex: } y = -2\left(-\frac{3}{4}\right)^2 - 3\left(-\frac{3}{4}\right) + 10 = 11\frac{1}{8}; \text{ vertex } \left(-\frac{3}{4}, 11\frac{1}{8}\right); \text{ points } (0, 10), (1, 5)$$



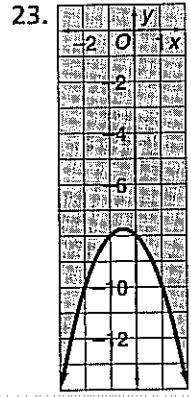
$$y = x^2 + 6x - 2; \text{ axis of symmetry: } x = -\frac{b}{2a} = -\frac{6}{2(1)} = -3; \text{ y-coordinate of vertex: } y = (-3)^2 + 6(-3) - 2 = -11; \text{ vertex } (-3, -11); \text{ points } (0, -2), (-1, -7)$$



$y \leq 3x^2 + x - 5$; boundary curve $y = 3x^2 + x - 5$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{1}{2(3)} = -\frac{1}{6}$; y-coordinate of vertex: $y = 3\left(-\frac{1}{6}\right)^2 + \left(-\frac{1}{6}\right) - 5 = -5\frac{1}{12}$; vertex $(-\frac{1}{6}, -5\frac{1}{12})$; points $(0, -5)$, $(1, -1)$; solid line and shade below



$y > 3x^2 + x - 5$; boundary curve $y = 3x^2 + x - 5$, same as Exercise 21; dashed line and shade above



$y \geq -x^2 - x - 8$; boundary curve $y = -x^2 - x - 8$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-1}{2(-1)} = -\frac{1}{2}$; y-coordinate of vertex: $y = -\left(-\frac{1}{2}\right)^2 - \left(-\frac{1}{2}\right) - 8 = -7\frac{3}{4}$; vertex $(-\frac{1}{2}, -7\frac{3}{4})$; points $(0, -8)$, $(1, -10)$; solid line and shade above

24. $\sqrt{86}$, irrational; $\sqrt{86} \approx 9.27$ 25. $-\sqrt{121}$, rational; $-\sqrt{121} = -11$ 26. $\pm\sqrt{\frac{1}{2}}$, irrational; $\pm\sqrt{\frac{1}{2}} \approx \pm 0.71$

27. $\sqrt{2.55}$, irrational; $\sqrt{2.55} \approx 1.60$ 28. $-\sqrt{\frac{4}{25}}$, rational; $-\sqrt{\frac{4}{25}} = -\frac{2}{5}$

29. $-\sqrt{47}$, irrational; $-\sqrt{47} \approx -6.86$

30. $\sqrt{0.36}$, rational; $\sqrt{0.36} = 0.6$ 31. $\sqrt{140}$, irrational; $\sqrt{140} \approx 11.83$ 32. $-\sqrt{1}$, rational; $-\sqrt{1} = -1$

33. $\sqrt{196}$, rational; $\sqrt{196} = 14$ 34. $6(x^2 - 2) = 12$; $x^2 - 2 = 2$; $x^2 = 4$; $x = \pm 2$; $x = 2$ or $x = -2$

35. $-5m^2 = -125$; $m^2 = 25$; $m = \pm 5$; $m = 5$ or $m = -5$

36. $9(w^2 + 1) = 9$; $w^2 + 1 = 1$; $w^2 = 0$; $w = 0$

37. $3r^2 + 27 = 0$; $3r^2 = -27$; $r^2 = -9$; no solution

38. $x^2 + 7x + 12 = 0$; $(x + 4)(x + 3) = 0$; $x + 4 = 0$ or $x + 3 = 0$; $x = -4$ or $x = -3$ 39. $5x^2 - 10x = 0$;

$5x^2 - 10x + 0 = 0$; $5x(x - 2) = 0$; $5x = 0$ or $x - 2 = 0$; $x = 0$ or $x = 2$ 40. $2x^2 - 9x = x^2 - 20$; $x^2 - 9x + 20 = 0$; $(x - 4)(x - 5) = 0$; $x - 4 = 0$ or $x - 5 = 0$; $x = 4$ or $x = 5$ 41. $2x^2 + 5x = 3$; $2x^2 + 5x - 3 = 0$;

$(2x - 1)(x + 3) = 0$; $2x - 1 = 0$ or $x + 3 = 0$; $2x = 1$ or $x = -3$; $x = \frac{1}{2}$ or $x = -3$ 42. $3x^2 - 5x = -3x^2 + 6$;

$6x^2 - 5x - 6 = 0$; $(3x + 2)(2x - 3) = 0$; $3x + 2 = 0$ or $2x - 3 = 0$; $3x = -2$ or $2x = 3$; $x = -\frac{2}{3}$ or $x = \frac{3}{2} = 1\frac{1}{2}$

43. $x^2 - 5x + 4 = 0$; $(x - 1)(x - 4) = 0$; $x - 1 = 0$ or $x - 4 = 0$; $x = 1$ or $x = 4$ 44. $x^2 + 6x - 5 = 0$; $x^2 + 6x = 5$; $x^2 + 6x + 9 = 5 + 9$; $(x + 3)^2 = 14$; $x + 3 = \pm\sqrt{14} \approx \pm 3.74$; $x + 3 \approx 3.74$ or $x + 3 \approx -3.74$; $x \approx 0.74$ or $x \approx -6.74$ 45. $x^2 = 3x - 1$; $x^2 - 3x = -1$; $x^2 - 3x + \frac{9}{4} = -1 + \frac{9}{4}$; $\left(x - \frac{3}{2}\right)^2 = \frac{5}{4}$; $x - \frac{3}{2} = \pm\sqrt{\frac{5}{4}} \approx \pm 1.12$; $x - 1.5 \approx 1.12$ or $x - 1.5 \approx -1.12$; $x \approx 2.62$ or $x \approx 0.38$

46. $2x^2 + 7x = -6$; $x^2 + \frac{7}{2}x = -3$; $x^2 + \frac{7}{2}x + \frac{49}{16} = -3 + \frac{49}{16}$; $\left(x + \frac{7}{4}\right)^2 = \frac{1}{16}$; $x + \frac{7}{4} = \pm\sqrt{\frac{1}{16}} = \pm\frac{1}{4}$; $x + \frac{7}{4} = \frac{1}{4}$ or $x + \frac{7}{4} = -\frac{1}{4}$; $x = -\frac{6}{4} = -1\frac{1}{2}$ or $x = -\frac{8}{4} = -2$ 47. $A = \pi r^2$; $16 = \pi r^2$; $r^2 = \frac{16}{\pi}$; $r = \sqrt{\frac{16}{\pi}} \approx 2.3$; 2.3 in.

48. $A = \ell w$; $170 = (2w - 3)w$; $2w^2 - 3w - 170 = 0$; $(2w + 17)(w - 10) = 0$; $2w + 17 = 0$ or $w - 10 = 0$; $2w = -17$ or $w = 10$; $w = -8.5$ or $w = 10$; use $w = 10$, then $2w - 3 = 2(10) - 3 = 17$; 10 ft \times 17 ft

49. $x^2 - 10 = 3$; $x^2 + 0x - 13 = 0$; $b^2 - 4ac = 0^2 - 4(1)(-13) = 52 > 0$; 2 solutions 50. $3x^2 = 27$; $3x^2 + 0x - 27 = 0$; $b^2 - 4ac = 0^2 - 4(3)(-27) = 324 > 0$; 2 solutions 51. $x^2 + 3 = 2x$; $x^2 - 2x + 3 = 0$; $b^2 - 4ac = (-2)^2 - 4(1)(3) = 4 - 12 = -8 < 0$; 0 solutions 52. $x^2 + 10x = -25$; $x^2 + 10x + 25 = 0$; $b^2 - 4ac = 10^2 - 4(1)(25) = 100 - 100 = 0$; 1 solution

53. $4x^2 + 3x - 8 = 0$; $a = 4$, $b = 3$, $c = -8$; $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-3 \pm \sqrt{3^2 - 4(4)(-8)}}{2(4)} = \frac{-3 \pm \sqrt{137}}{8}$, $x = \frac{-3 + \sqrt{137}}{8} \approx 1.09$ or $x = \frac{-3 - \sqrt{137}}{8} \approx -1.84$

54. $2x^2 - 7x = -3$; $2x^2 - 7x + 3 = 0$; $a = 2$, $b = -7$, $c = 3$; $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-7) \pm \sqrt{(-7)^2 - 4(2)(3)}}{2(2)} = \frac{7 \pm \sqrt{25}}{4} = \frac{7 \pm 5}{4}$; $x = \frac{7+5}{4} = 3$ or $x = \frac{7-5}{4} = 0.5$

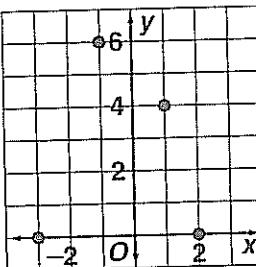
55. $-x^2 + 8x + 4 = 5$; $-x^2 + 8x - 1 = 0$; $a = -1$, $b = 8$, $c = -1$; $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-8 \pm \sqrt{8^2 - 4(-1)(-1)}}{2(-1)} = \frac{-8 \pm \sqrt{60}}{-2}$; $x = \frac{-8 + \sqrt{60}}{-2} \approx 0.13$ or $x = \frac{-8 - \sqrt{60}}{-2} \approx 7.87$

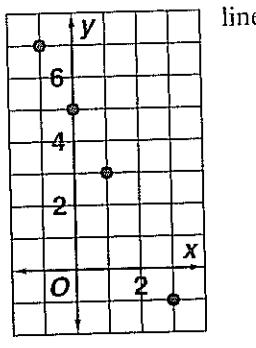
56. $9x^2 - 270 = 0$; $9x^2 = 270$; $x^2 = 30$; $x = \pm\sqrt{30} \approx \pm 5.48$; $x = 5.48$ or $x = -5.48$ 57. $5x^2 - 10 = x^2 + 90$; $4x^2 - 100 = 0$; $(2x - 10)(2x + 10) = 0$; $2x - 10 = 0$ or $2x + 10 = 0$; $2x = 10$ or $2x = -10$; $x = 5$ or $x = -5$; use factoring, because the equation is easily factorable.

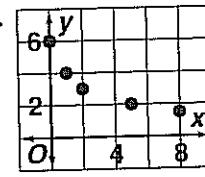
58. $9x^2 + 30x - 29 = 0$; $a = 9$, $b = 30$, $c = -29$; $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-30 \pm \sqrt{30^2 - 4(9)(-29)}}{2(9)} = \frac{-30 \pm \sqrt{1944}}{18}$; $x = \frac{-30 + \sqrt{1944}}{18} \approx 0.78$ or $x = \frac{-30 - \sqrt{1944}}{18} \approx -4.12$; use the quadratic formula, because the trinomial does not factor easily.

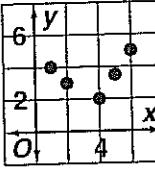
59. $2x^2 - 9x = x^2 - 20$; $x^2 - 9x + 20 = 0$; $(x - 4)(x - 5) = 0$; $x - 4 = 0$ or $x - 5 = 0$; $x = 4$ or $x = 5$; use factoring, because the equation is easily factorable. 60. $x^2 - 6x + 9 = 0$; $(x - 3)^2 = 0$; $x - 3 = 0$; $x = 3$; use factoring, because the equation is easily factorable. 61. $x^2 + 3x - 225 = 3x$; $x^2 - 225 = 0$; $x^2 = 225$; $x = \pm\sqrt{225} = \pm 15$; $x = 15$ or $x = -15$; use square roots, because the equation has no x term.

62. $x^2 + 8x = 4$; $x^2 + 8x + 16 = 4 + 16$; $(x + 4)^2 = 20$; $x + 4 = \pm\sqrt{20} \approx \pm 4.47$; $x + 4 \approx 4.47$ or $x + 4 \approx -4.47$; $x \approx 0.47$ or $x \approx -8.47$; complete the square, because the equation is in the form $x^2 + bx = c$. 63. $(p + 2)^2 = 400$; $p + 2 = \pm\sqrt{400} = \pm 20$; $p + 2 = 20$ or $p + 2 = -20$; $p = 18$ or $p = -22$; use $p = 18$; length = 18 ft; area = $(18 \text{ ft})^2 = 324 \text{ ft}^2$ 64. $0 = -16t^2 + 20t + 6$; $a = -16$, $b = 20$, $c = 6$; $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-20 \pm \sqrt{20^2 - 4(-16)(6)}}{2(-16)} = \frac{-20 \pm \sqrt{784}}{-32} = \frac{-20 \pm 28}{-32}$; $x = \frac{-20 + 28}{-32} = -0.25$ or $x = \frac{-20 - 28}{-32} = 1.5$, use $x = 1.5$; 1.5 seconds

65.  quadratic

66.  linear

67.  exponential

68.  quadratic

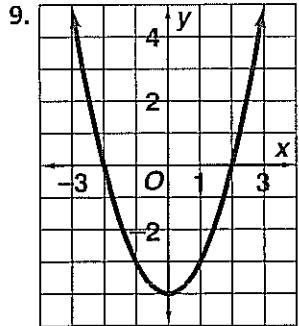
69. Test for a common ratio: $5 \div 2.5 = 2$, $10 \div 5 = 2$, $20 \div 10 = 2$, $40 \div 20 = 2$; common ratio is 2, so write an exponential equation: $y = 5(2)^x$. 70. Test for a common difference: $-2 - (-5) = 3$, $1 - (-2) = 3$, $4 - 1 = 3$, $7 - 4 = 3$; common difference is 3, so write a linear equation: $y = 3x - 2$. 71. Test for a common second difference: $1 - 4 = -3$, $0 - 1 = -1$, $1 - 0 = 1$, $4 - 1 = 3$, and $-1 - (-3) = 2$, $-1 - (-2) = 1$, $1 - (-1) = 2$, $3 - 1 = 2$; common second difference is 2, so write a quadratic equation: $y = (x + 1)^2$. 72. Test for a common ratio: $5 \div 0.5 = 10$, $50 \div 5 = 10$, $500 \div 50 = 10$, $5000 \div 500 = 10$; common ratio is 10, so write an exponential equation: $y = \frac{1}{2}(10)^x$.

CHAPTER TEST

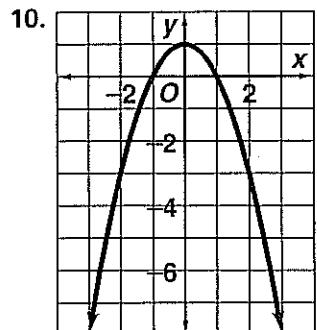
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- The graph is the same as $y = x^2$, but shifted down 3 units, so $y = x^2 - 3$; D.
- The graph is a parabola through the origin and opening downward, so $y = ax^2$

with $a < 0$; choose $y = -2x^2$. C. 3. The graph is a parabola through the origin and opening upward, so $y = ax^2$ with $a > 0$; choose $y = 3x^2$; A. 4. The graph is a parabola that opens downward and is shifted up 1 unit, so choose $y = -3x^2 + 1$; B. 5. $y = 3x^2 - 7$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{0}{2(3)} = 0$, $x = 0$; y-coordinate of vertex: $y = 3(0)^2 - 7 = -7$; vertex $(0, -7)$; $a = 3 > 0$, so the parabola opens upward and the vertex is a minimum. 6. $y = x^2 - 3x + 2$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{-3}{2(1)} = 1.5$, $x = 1.5$; y-coordinate of vertex: $y = (1.5)^2 - 3(1.5) + 2 = -0.25$; vertex $(1.5, -0.25)$; $a = 1 > 0$, so the parabola opens upward and the vertex is a minimum. 7. $y = -2x^2 + 10x - 1$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{10}{2(-2)} = 2.5$, $x = 2.5$; y-coordinate of vertex: $-2(2.5)^2 + 10(2.5) - 1 = 11.5$; vertex $(2.5, 11.5)$; $a = -2 < 0$, so the parabola opens downward and the vertex is a maximum. 8. $y = \frac{1}{2}x^2 + 6x$; axis of symmetry: $x = -\frac{b}{2a} = -\frac{6}{2(\frac{1}{2})} = -6$; y-coordinate of vertex: $y = \frac{1}{2}(-6)^2 + 6(-6) = -18$; vertex $(-6, -18)$; $a = \frac{1}{2} > 0$, so the parabola opens upward and the vertex is a minimum.



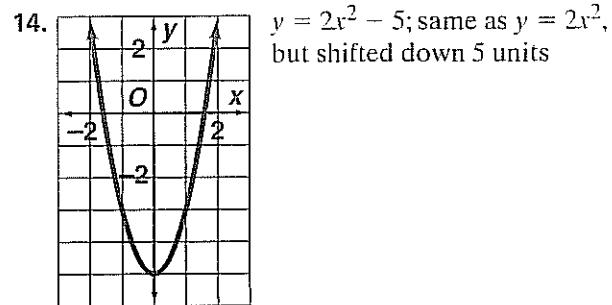
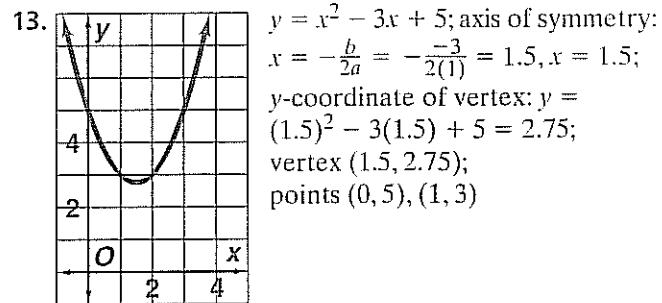
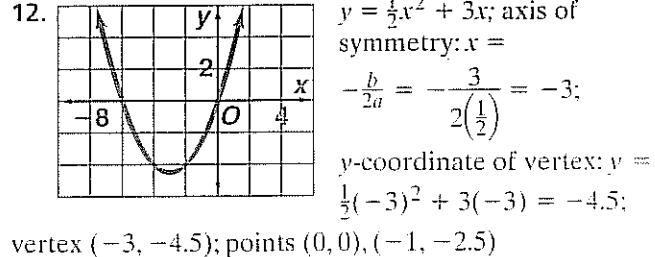
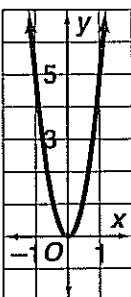
$$y = x^2 - 4; \text{ same as } y = x^2, \text{ but shifted down 4 units}$$



$$y = -x^2 + 1; \text{ same as } y = -x^2, \text{ but shifted up 1 unit}$$

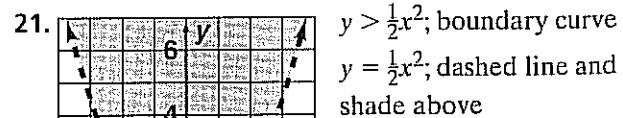
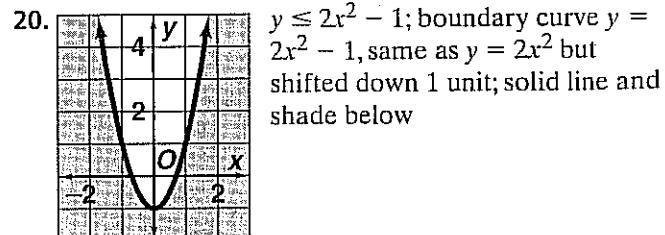
11.

x	$y = 5x^2$	(x, y)
0	$5(0)^2 = 0$	$(0, 0)$
1	$5(1)^2 = 5$	$(1, 5)$
2	$5(2)^2 = 20$	$(2, 20)$



15. Answers may vary. Sample: You can tell how wide it is and whether it opens upward or downward.

16. $y = 5x^2$; $b^2 - 4ac = 0^2 - 4(5)(0) = 0$; 1 x-intercept
 17. $y = 3x^2 + 10$; $b^2 - 4ac = 0^2 - 4(3)(10) = -120 < 0$; 0 x-intercepts
 18. $y = -2x^2 + x + 7$; $b^2 - 4ac = 1^2 - 4(-2)(7) = 57 > 0$; 2 x-intercepts
 19. $y = x^2 - 4x$; $b^2 - 4ac = (-4)^2 - 4(1)(0) = 16 > 0$; 2 x-intercepts



$$22. \sqrt{1.44} = 1.2$$

$$23. \sqrt{1600} = 40$$

$$24. \sqrt{\frac{4}{9}} = \frac{2}{3}$$

$$25. \sqrt{0.04} = 0.2$$

26. $\sqrt{25} < \sqrt{28} < \sqrt{36}$, so $5 < \sqrt{28} < 6$; between 5 and 6 27. $\sqrt{121} < \sqrt{136} < \sqrt{144}$, so $11 < \sqrt{136} < 12$; between 11 and 12 28. $\sqrt{324} < \sqrt{332} < \sqrt{361}$, so $18 < \sqrt{332} < 19$; between 18 and 19

29. $-\sqrt{9} < -\sqrt{8.99} < -\sqrt{4}$, so $-3 < -\sqrt{8.99} < -2$; between -3 and -2 30. $x^2 + 4x = -4$; $x^2 + 4x + 4 = 0$; $b^2 - 4ac = 4^2 - 4(1)(4) = 16 - 16 = 0$; 1 solution

31. $x^2 + 8 = 0$; $x^2 = -8$; no solution 32. $2x^2 + x = 0$; $b^2 - 4ac = 1^2 - 4(2)(0) = 1 > 0$; 2 solutions

33. $3x^2 - 9x = -5$; $3x^2 - 9x + 5 = 0$; $b^2 - 4ac = (-9)^2 - 4(3)(5) = 81 - 60 = 21 > 0$; 2 solutions

34. $kx^2 - 10x + 25 = 0$; $b^2 - 4ac = 0$; $(-10)^2 - 4k(25) = 0$; $100 - 100k = 0$; $100 = 100k$; $k = 1$ 35. $2x^2 = 50$; $x^2 = 25$; $x = \pm\sqrt{25} = \pm 5$; $x = 5$ or $x = -5$

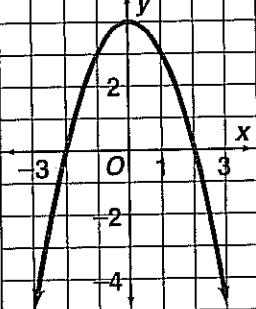
36. $-3x^2 + 7x = -10$; $3x^2 - 7x - 10 = 0$; $(3x - 10)(x + 1) = 0$; $3x - 10 = 0$ or $x + 1 = 0$; $3x = 10$ or $x = -1$; $x = \frac{10}{3} \approx 3.33$ or $x = -1$

37. $x^2 + 6x + 9 = 25$; $(x + 3)^2 = 25$; $x + 3 = \pm\sqrt{25} = \pm 5$; $x + 3 = 5$ or $x + 3 = -5$; $x = 2$ or $x = -8$

38. $-x^2 - x + 2 = 0$; $(-x + 1)(x + 2) = 0$; $-x + 1 = 0$ or $x + 2 = 0$; $x = 1$ or $x = -2$ 39. $x^2 + 4x = 1$;

$x^2 + 4x + 4 = 1 + 4$; $(x + 2)^2 = 5$; $x + 2 = \pm\sqrt{5} \approx \pm 2.24$; $x + 2 \approx 2.24$ or $x + 2 \approx -2.24$; $x \approx 0.24$ or $x \approx -4.24$

40. $12x^2 + 16x - 28 = 0$; $3x^2 + 4x - 7 = 0$; $(3x + 7)(x - 1) = 0$; $3x + 7 = 0$ or $x - 1 = 0$; $3x = -7$ or $x = 1$; $x = -\frac{7}{3} \approx -2.33$ or $x = 1$

41.  Answers may vary. Sample:
 $y = -x^2 + 4$

42. $V = \pi r^2 h$; $140 = \pi r^2 \cdot 10$; $140 = 10\pi r^2$; $r^2 = \frac{140}{10\pi} = \frac{14}{\pi}$; $r = \sqrt{\frac{14}{\pi}} \approx 2.1$; 2.1 ft 43. $A = \ell w$; $800 = (2w)w$; $800 = 2w^2$; $w^2 = 400$; $w = \sqrt{400} = 20$; $2w = 2(20) = 40$; $w = 20$ ft, $\ell = 40$ ft 44. quadratic; $y = \frac{1}{2}x^2$ 45. exponential; $y = \frac{1}{2}(2)^x$ 46. linear; $y = x + 2$ 47. exponential; $y = 40(0.5)^x$

STANDARDIZED TEST PREP page 573

$$1. 3x^2 - 5x + 1 = 0; a = 3, b = -5, c = 1;$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-(-5) \pm \sqrt{(-5)^2 - 4(3)(1)}}{2(3)} =$$

$$\frac{5 \pm \sqrt{13}}{6}; x = \frac{5 + \sqrt{13}}{6} \approx 1.43 \text{ or } x = \frac{5 - \sqrt{13}}{6} \approx 0.23; \text{D}$$

$$2. y = 5x^2 - 2x + 3; x = -\frac{b}{2a} = -\frac{-2}{2(5)} = \frac{1}{5}; \text{F}$$

3. $\sqrt{49} < \sqrt{52} < \sqrt{64}$, so $7 < \sqrt{52} < 8$; C

4. slope $-\frac{1}{3}$ and through $(0, 6)$: $y - 6 = -\frac{1}{3}(x - 0)$; $y = -\frac{1}{3}x + 6$; test $(9, 3)$: $3 \stackrel{?}{=} -\frac{1}{3}(9) + 6$, $3 \stackrel{?}{=} -3 + 6$, $3 = 3$; F 5. $P(\text{not 1 or 2}) = P(3, 4, 5, \text{or } 6) = \frac{4}{6} = \frac{2}{3}$; D

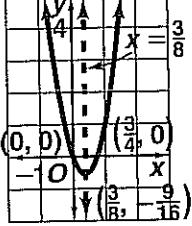
6. $3x^2 - 4x - 3 = 0$; $b^2 - 4ac = (-4)^2 - 4(3)(-3) = 16 + 36 = 52$; I 7. $(3x - 1)(5x + 3) = 15x^2 + 9x - 5x - 3 = 15x^2 + 4x - 3$; D 8. $x^2 + 4x + 4 = 49$; $(x + 2)^2 = 49$; $x + 2 = \pm\sqrt{49} = \pm 7$; $x + 2 = 7$ or $x + 2 = -7$; $x = 5$ or $x = -9$; I 9. Solve the second equation for y : $6y - x = 24$; $6y = x + 24$; $y = \frac{1}{6}x + 4$; the two lines have different slopes, so they will intersect in 1 point; B 10. Add the two equations: $3y = 9$, $y = 3$; substitute 3 for y in the first equation: $x + 3 = 5$, $x = 2$; C

11. $x^2 + x - 20 = 0$; discriminant: $b^2 - 4ac = 1^2 - 4(1)(-20) = 81$; solutions: $(x + 5)(x - 4) = 0$, $x + 5 = 0$ or $x - 4 = 0$, $x = -5$ or $x = 4$, sum = $-5 + 4 = -1$; 81 > -1 ; A 12. slope = $\frac{6 - 3}{4 - (-1)} = \frac{3}{5} = 0.6$ 13. percent of increase = $\frac{20 - 12}{12} \approx 0.67$, or 67%; 67

14. [2] $(2w - 6)w = 140$; $2w^2 - 6w - 140 = 0$; $w^2 - 3w - 70 = 0$; $(w - 10)(w + 7) = 0$; $w = 10$; 10 m by 14 m [1] correct answer but no work shown

15. [2] straight line, U-shaped curve that opens up or down, V-shaped curve that opens up or down (OR equivalent descriptions) [1] two correct descriptions

16. [2] $9a + 3b - 3 - 4a + 7 - 8b = (9 - 4)a + (3 - 8)b - 3 + 7 = 5a - 5b + 4$ [1] correct answer but no work shown

17.  vertex: $(\frac{3}{8}, -\frac{9}{16})$
x-intercepts: 0 and $\frac{3}{4}$
axis of symmetry: $x = \frac{3}{8}$

REAL-WORLD SNAPSHOTS pages 574–575

Activity 1 Answers may vary. Sample:

a. Let $R_1 = 31$ ft, $R_2 = 38$ ft. b. $d = 2\sqrt{(R_2)^2 - (R_1)^2} = 2\sqrt{38^2 - 31^2} = 2\sqrt{483} \approx 44$ ft c. Let $R_1 = 112$ ft, $R_2 = 119$ ft; $d = 2\sqrt{(R_2)^2 - (R_1)^2} = 2\sqrt{119^2 - 112^2} = 2\sqrt{1617} \approx 80$ ft.

Activity 2 a–b. Answers may vary. Sample:

a. Let $R = 118$ ft; $F = \frac{1}{8}(\pi^2 W N^2 R)$; $150 = \frac{1}{8}(\pi^2 \cdot 150 \cdot N^2 \cdot 118)$; $N \approx 0.082$ revolutions/s
b. $F = \frac{1}{8}(\pi^2 W N^2 R)$; $20 = \frac{1}{8}(\pi^2 \cdot 20 \cdot N^2 \cdot 118)$; $N \approx 0.082$ revolutions/s; $N \approx 298$ revolutions/h
c. They are the same.