Selected Answers

Chapter 1

Chapter 1 Maintaining Mathematical Proficiency (p. 1)
1. 47  2. -46  3. $\frac{3}{2}$  4. 4  5. 13  6. 0

7.
[Graph showing a function with points: (0, 6), (3, 6), (3, 0)]

8.
[Graph showing a function with points: (0, 4), (1, 3), (-2, 2)]

9. [Graph showing a function with points: (-4, 5), (-5, 4), (-1, 4)]

10. Sample answer: $12 + 18 \div 3$ equals 18 when division is performed first and 10 when addition is performed first; yes; If the point (3, 2) is translated up 3 units then reflected across the x-axis, the new coordinate is (3, -5). If it is reflected across the x-axis first then translated up 3, the new coordinate is (3, 1).

1.1 Vocabulary and Core Concept Check (p. 7)
1. endpoints, bounded

1.1 Maintaining Mathematical Progress and Modeling with Mathematics (pp. 7–8)
3. {0, 1, 2, 3, 4, 5, 6, 7, 8, 9}  5. {51, 52, 53, 54, ...}
7. (3, 9)  9. [-13, $\infty$]
11. (-4, 6)  13. (-$\infty$, 3)
15. [-10, 10]
17.
[Number line from -3 to 15 with tick marks at intervals of 2]

19. [Number line from -5 to 20 with tick marks at intervals of 5]

21. $\{x \mid -5 \leq x < 16\}$  23. $\{x \mid x \leq -4 \text{ or } x \geq 4\}$
25. $\{x \mid x \in \mathbb{Z} \text{ and } x < -20\}$  27. $\{x \mid x \neq 100\}$
29. The interval includes -8; $\{x \mid x \leq -8\}$
31. [-282, 20,320]; $\{x \mid -282 \leq x \leq 20,320\}$
33. yes; Interval notation includes all real numbers.
35. a. {0, 2, 4, 6, ...}; $\{x \mid x \in \mathbb{W} \text{ and } x \text{ is even}\}$ The set does not include all real numbers in an interval.
b. (-$\infty$, -4); $\{x \mid x < -4\}$; There are infinitely many elements in the set.
c. (-$\infty$, 40) or [60, $\infty$]; $\{x \mid x \leq 40 \text{ or } x \geq 60\}$; There are infinitely many elements in the set.
37. [36, 96]

1.2 Vocabulary and Core Concept Check (p. 14)
1. parent function

1.2 Monitoring Progress and Modeling with Mathematics (pp. 14–16)
3. absolute value; The graph is a vertical stretch with a translation 2 units left and 8 units down; The domain of each function is all real numbers, but the range of $f$ is $y \geq -8$, and the range of the parent function is $y \geq 0$.
5. linear; The graph is a vertical stretch and a translation 2 units down; The domain and range of each function is all real numbers.

7. [Graph showing a function $y = 2x + 43$]

linear; The temperature is increasing by the same amount at each interval.

9. [Graph showing a function $g(x) = x + 4$]

The graph of $g$ is a vertical translation 4 units up of the parent linear function.
21. The graph of \( f \) is a vertical stretch of the parent quadratic function.

23. The graph of \( h \) is a vertical shrink of the parent linear function.

25. The graph of \( h \) is a vertical stretch of the parent absolute value function.

27. The graph of \( f \) is a vertical stretch followed by a translation 1 unit down of the parent linear function.

29. The graph of \( h \) is a vertical stretch and a reflection in the \( x \)-axis followed by a translation 1 unit down of the parent absolute value function.

31. The graph of \( g \) is a vertical shrink followed by a translation 6 units down of the parent quadratic function.
33. The graph of \( f \) is a reflection across the y-axis followed by a translation 3 units left and \( \frac{1}{5} \) unit up of the parent quadratic function.

35. It is a vertical stretch, not shrink. The graph is a reflection in the x-axis followed by a vertical stretch of the parent quadratic function.

37. (2, -1), (-1, -4), (2, -5)

39. absolute value; domain is all real numbers; range is \( y \geq -1 \)

41. linear; domain is all real numbers; range is all real numbers

43. quadratic; domain is all real numbers; range is \( y \geq -2 \)

45. absolute value; 8 mi/h

47. no; \( f \) is shifted right and \( g \) is shifted down.

49. yes; Shifting the parent linear function down 2 units will create the same graph as shifting it 2 units right.

51. a. quadratic
   b. 0; At the moment the ball is released, 0 seconds have passed.
   c. 5.2; Because \( f(t) \) represents the height of the ball, find \( f(0) \).

53. a. vertical translation; The graph will be shifted 3 units down.
   b. horizontal translation; The graph will be shifted 8 units right.
   c. both; The graph will be shifted 2 units right and 4 units up.
   d. neither; The graph will have a vertical stretch.

1.2 Maintaining Mathematical Proficiency (p. 16)

55. yes
57. no
59. \( x \)-intercept: 0; \( y \)-intercept: 0
61. \( x \)-intercept: \( \frac{1}{3} \); \( y \)-intercept: 1

1.3 Vocabulary and Core Concept Check (p. 22)

1. shrink

1.3 Monitoring Progress and Modeling with Mathematics (pp. 22-24)

3. \( g(x) = x - 1 \)

5. \( g(x) = \left| 4x + 3 \right| \)

7. \( g(x) = 4 - \left| x - 2 \right| \)

9. \( f \) could be translated 3 units up or 3 units right.

11. \( g(x) = 5x - 2 \)

13. \( g(x) = \left| 6x \right| - 2 \)

15. \( g(x) = -3 + \left| -x - 11 \right| \)

17. \( g(x) = 5x + 10 \)

19. \( g(x) = \left| 4x \right| + 4 \)

21. \( g(x) = -\left| x - 4 \right| + 1 \)

23. C; The graph has been translated left.

25. D; The graph has been translated up.

27. \( g(x) = 2x + 1 \)

29. \( g(x) = \left( \frac{1}{2} \right)x + 2 \)

31. \( g(x) = -\left| 2x \right| - 8 \)

33. Translating a graph to the right requires subtraction, not addition; \( g(x) = \left| x - 3 \right| + 2 \)

35. no; Suppose a graph contains the point (3, 2) and is translated up 3 units then reflected across the x-axis. The new coordinate is (3, -5). If it is reflected across the x-axis first then translated up 3, the new coordinate is (3, 1).

37. The graph has been translated 6 units left; \( A = 9 \)

39. The graph has been reflected across the x-axis; \( A = 16 \)

41. a. \( f(x) + (c - b) \)
   b. \( f \left( \frac{x + c - b}{m} \right) + b \)

43. vertical stretch, translation, reflection; Sample answer: \(-4 \left| x \right| - 2 = -4 \left| x \right| + 2 \)

45. \( a = -2, b = 1, c = 0 \)

1.3 Maintaining Mathematical Proficiency (p. 24)

47. \(-21, -16, -10, 22, -32 \)

49. \(-3, -2, -1, 0, 2 \)

51. \( b = 7 \)

53. \( a = 3 \)

1.4 Vocabulary and Core Concept Check (p. 32)

1. an apparent solution that must be rejected because it does not satisfy the original equation

1.4 Monitoring Progress and Modeling with Mathematics (pp. 32-34)

3. \( 9 \)

5. \( 0 = 7 \)

7. \(-35 \)

9. \( 9 \)

11. \( w = -6, w = 6; \)

13. no solution

15. \( m = -10, m = 4; \)

17. \( d = -5, d = 5; \)

19. \( b = -3.5, b = 6; \)

21. no solution

23. \( s = 20; \)

25. a. \( \left| d - 92,950,000 \right| = 1,550,000 \)
   b. \( \left| d - 92,950,000 \right| = 1,550,000 \)

27. B

29. C

31. \( \left| x - 13 \right| = 5 \)

33. \( \left| x - 5.5 \right| = 3.5 \)

35. \( n = 3, n = 5 \)

37. \( b = 3, b = 5 \)

38. \( k = -0.4, k = 6 \)

39. \( p = \frac{2}{3}, p = 10 \)

41. \( h = 0.25 \)

43. \( f = -1 \)

45. 5 sec, 7.5 sec

47. a. \( \left| x - 32 \right| = 5; 27\% \), 37\%
   b. no; \( \frac{1}{3} \) \( \left( \frac{33 \%}{2} \right) \) falls within the range of possible values.

49. The absolute value cannot be negative. So, there is no solution.

51. No solution: \( \left| x - 2 \right| + 6 = 0, \left| x - 6 \right| - 5 = -9 \)

One solution: \( \left| x - 1 \right| + 4 = 4, \left| x + 5 \right| - 8 = -8 \)

Two solutions: \( \left| x + 8 \right| + 2 = 7, \left| x + 3 \right| - 1 = 0 \)

53. always; Square roots of the same number have the same absolute value.

55. sometimes; The equation will only have two solutions if \( p \) is positive.
57. Absolute value equations will have no solution when the absolute value is equal to a negative number, one solution when the absolute value is equal to zero, and two solutions when the absolute value is equal to a positive number; 
Sample answer: \(|x + 12| = -2\) has no solution, \(|x + 12| = 0\) has one solution, and \(|x + 12| = 2\) has two solutions.
59. \(x = 1, x = -5\); Interpret \(|x + 2|\) as a single quantity and solve for it, then solve the resulting absolute value equation.
61. If \(c = d\), then the absolute value expression will be equal to 0; If \(c > d\), then \(d - c\) will be negative. When this value is divided by a negative value of \(a\), the result will be positive.

1.4 Maintaining Mathematical Proficiency (p. 34)
63. \(x > 5\)
65. \(y > -6\) and \(y < 11\)
67. \(x < -5\) or \(x > 2\)
69. 6 in. 71. 9 cm

1.5 Vocabulary and Core Concept Check (p. 39)
1. yes; Because the absolute value must be positive, all values will be greater than \(-6\).

1.5 Monitoring Progress and Modeling with Mathematics (pp. 39–40)
3. \(-3 < x < 3\)
5. \(d < -12\) or \(d > -6\)
7. all real numbers
9. no solution
11. \(r \leq -\frac{2}{3}\) or \(t \geq 3\)
13. \(m > 20\) or \(m < 8\)
15. \(-4 \leq w \leq -\frac{4}{3}\)
17. \(f < 3\) or \(f > 3\)
19. \(|w - 500| \leq 30\); 470 to 530 words
21. did not rewrite the absolute value inequality as a compound inequality; \(-20 < x - 5 < 20\); \(-15 < x < 25\)
23. \(n < 6\); \(-6 < n < 6\)
25. \(\left|\frac{1}{2}n - 14\right| \leq 5\); \(18 \leq n \leq 38\)
27. the gasket with a weight of 0.53 lb
29. \(\frac{1}{2} \cdot 4(x + 6) - 2 \cdot 6 < 2; -1 < x < 1\)
31. true
33. false; It has to be a solution of \(x + 3 \leq -8\) or \(x + 3 \geq 8\).
35. no; If \(n\) is 0, the statement is false.
37. no solution; An absolute value cannot be negative; all real numbers; An absolute value must be positive or zero, so it will always be greater than any negative number.

39. The solution of \(|x| < 5\) is the set of values that make both of 2 inequalities true, the solution of \(|x| > 5\) is the set of values that make either of 2 inequalities true.

1.5 Maintaining Mathematical Proficiency (p. 40)
41. 7 43. -2
45.

1.6 Vocabulary and Core Concept Check (p. 46)
1. slope-intercept

1.6 Monitoring Progress and Modeling with Mathematics (pp. 46–48)
3. \(\frac{1}{2}y\); The tip increases $0.20 for each dollar spent on the meal.
5. \(50x + 100\); The balance increases $50 each week.
7. \(55x\); The number of words increases by 55 each minute.
9. Greenville Journal; 5 lines
11. The original balance of $100 should have been included; After 10 years, the increase in balance will be $70, resulting in a new balance of $170.
13. yes; Sample answer: \(y = 4.25x + 1.75\); \(y = 65.5\); After 15 minutes, you have burned 65.5 calories.
15. yes; Sample answer: \(y = -4.6x + 96\); \(y = 27\); After 15 hours, the battery will have 27% of life remaining.
17. \(y = 380.0x + 11,290\); $16,990; The annual tuition increases about $380 each year and the cost of tuition in 2005 is about $11,290.
19. \(y = 0.42x + 1.44\); \(r = 0.61\); weak positive correlation
21. \(y = -0.45x + 4.26\); \(r = -0.67\); weak negative correlation
23. \(y = 0.61x + 0.10\); \(r = 0.95\); strong positive correlation
25. a. Sample answer: height and weight; temperature and ice cream sales; Correlation is positive because as the first goes up, so does the second.
   b. Sample answer: miles driven and gas remaining; hours used and battery life remaining; Correlation is negative because as the first goes up, the second goes down.
   c. Sample answer: age and length of hair; typing speed and shoe size; There is no relationship between the first and second.
27. no; Because \(r\) is close to 0, the points do not lie close to the line.
29. It is negative; As \(x\) increases, \(y\) increases, so \(z\) decreases.
31. 2.2 mi

1.6 Maintaining Mathematical Proficiency (p. 48)
33. \((16, -41)\)
35. \((1, \frac{1}{2})\)
37. \((\frac{16}{17}, \frac{15}{17})\)

Chapter 1 Review (pp. 50–52)
1. \((-\infty, 48]\)
2. \((6, \infty)\)
3. \((-8, 16)\)
4. \(\{x \mid x < -6\ or \ x > 21\}\)
10. The graph of \( g \) is a vertical stretch by a factor of 3 followed by a reflection in the \( x \)-axis and a translation 3 units left.

11. \( g(x) = -|x + 4| \)

12. \( g(x) = \frac{1}{2}|x| + 2 \)

13. \( g(x) = -x - 3 \)

14. \( y = -20, y = 14 \)

15. \( w = -\frac{1}{5}, w = 3 \)

16. \( x = -1 \)

17. \( m \geq 10 \) or \( m \leq -10 \)

18. no solution

19. \( 3 \leq f \leq 9 \)

20. \( b < -12 \) or \( b > -4 \)

21. \( -\frac{7}{5} < g < 1 \)

22. all real numbers

23. \( y = 0.03x + 1.23 \)

24. \( y = 0.35x; 15.75 \) mi

Chapter 2

Chapter 2 Maintaining Mathematical Proficiency (p. 57)

1. \( y = x + 4 \)

2. \( y = -4x + 6 \)

3. \( y = \frac{1}{3}x - 4 \)

4. \( y = \frac{1}{6} \)

5. \( y = \frac{x - 6}{4 + z} \)

6. \( y = \frac{z}{2 + 6x} \)

7. The graph of \( f \) is a reflection in the \( x \)-axis followed by a translation 3 units down of the parent absolute value function.

8. The graph of \( f \) is a translation 1 unit down of the parent absolute value function.

9. The graph of \( f \) is a vertical shrink by a factor of \( \frac{1}{2} \) of the parent quadratic function.

10. The graph of \( g \) is a translation 3 units up of the parent linear function.

11. The graph of \( g \) is a translation 1 unit down of the parent absolute value function.

12. The graph of \( g \) is a translation 3 units up of the parent constant function.
11. no; The point (0, 0) may lie on a boundary line.

2.1 Vocabulary and Core Concept Check (p. 64)

1. ordered triple

2.1 Monitoring Progress and Modeling with Mathematics (pp. 64–66)

3. no; The ordered triple does not satisfy Equation 3.

5. (−20, 5) 7. \( \begin{pmatrix} \frac{11}{13}, -\frac{1}{13}, -\frac{9}{13} \end{pmatrix} \)

9. (10, −20, −5) 11. (1, 4, 8) 12. (1, 1, −9)

13. The negative sign should have been distributed after substituting for \( z \);
   
   \[ z = 11 - 3x - 2y \]
   
   \[ x - y + 11x + 2y = -2 \]
   
   \[ 4x + y = 9 \]

17. no solution 19. \((-8x + 17, 19z - 36, z)\)

21. \( \left( \frac{-5x + 17}{2}, \frac{-11x + 33}{2} \right) \)

23. Peanuts cost $4 per pound, cashews cost $10 per pound, and almonds cost $6 per pound.

25. Sample answer: \( x + 3y + 5z = 7, 2x + 5y + 13z = 11, -5x + 6y + 3z = 13 \); It is easiest to solve Equation 1 for \( x \) because its coefficient is one.

27. 1%

29. \( \ell + m + n = 65, n = \ell + m - 15, \ell = \frac{3}{4}m; \ell = 10 \text{ ft,} \)
   
   \( m = 30 \text{ ft,} \ n = 25 \text{ ft} \)

31. Sample answer: \( 2x + y - z = -9, -x + 4y + 3z = 14, x + 2y - 2z = -6 \)

33. 350 ft²

35. \( a. r + \ell + i = 12, 2.50r + 4\ell + 2i = 32, r = 2\ell + 2i \)
   
   b. 8 roses, 2 lilies, 2 irises
   
   c. no; 8 roses, 4 lilies, 0 irises; 8 roses, 0 lilies, 4 irises; 8 roses, 3 lilies, 1 iris

37. a. no solution
   
   b. one solution, infinitely many solutions, no solution
   
   c. one solution, infinitely many solutions, no solution

39. \( t + a = g, t + b = a, 2g = 3b \); 5 tangerines

2.2 Maintaining Mathematical Proficiency (p. 66)

41. (0, 3) 43. (3, 1)

2.2 Vocabulary and Core Concept Check (p. 71)

1. In each method, you eliminate one variable to obtain a linear system in two variables.

2.2 Monitoring Progress and Modeling with Mathematics (pp. 71–72)

3. no solution 5. no solution 7. \((z - 1, 1, z)\)

9. The entire second equation should be multiplied by 4, not just the \( x \)-term.

\[ 4x - y + 2z = -18 \]

\[ -4x + 8y + 4z = 11 \]

\[ 7y + 6z = -7 \]

11. \((3, 2, 1)\) 13. no solution 15. \((x, x + 2, 3x + 1)\)

17. A small pizza costs $5, a liter of soda costs $1, and a salad costs $3.

19. 280 adult tickets, 40 student tickets, 80 children tickets

21. a. elimination; When you subtract any two pairs of equations, you obtain a system in terms of \( y \) and \( z \) only.

b. Gaussian elimination; Equation 3 is divisible by 2, so you can write the system in row-echelon form without introducing fractions.

23. \( a = 12, b = -4, c = 10; \) These are the values you obtain when you substitute \(-1\) for \( x\), \(2\) for \( y\), and \(-3\) for \( z\).

25. a. Sample answer: \( a = -1, b = -1, c = -1\); Use elimination on equations 1 and 2.

b. Sample answer: \( a = 4, b = 4, c = 5\); The solution is \( \left( \frac{3}{7}, -\frac{2}{7}, 2 \right) \).

b. Sample answer: \( a = 5, b = 5, c = 5\); Use elimination on equations 1 and 2.

2.3 Maintaining Mathematical Proficiency (p. 72)

27. (1.86, 1.43) 29. (5, −4)

2.3 Vocabulary and Core Concept Check (p. 79)

1. augmented

2.3 Monitoring Progress and Modeling with Mathematics (pp. 79–80)

3. \[ \begin{bmatrix} 3 \ -4 \ 0 \ 7 \\ 9 \ 11 \ 10 \ 2 \times 3 \end{bmatrix} \]

5. \[ \begin{bmatrix} 1 \ 8 \ -7 \ 12 \\ 5 \ 9 \ 5 \ 15 ; 3 \times 4 \\ -8 \ -3 \ 6 \ 1 \end{bmatrix} \]

7. \[ \begin{bmatrix} 1 \ -1 \ 1 \ 14 \\ 6 \ 0 \ -5 \ 13 ; 3 \times 4 \\ -3 \ 7 \ 8 \ -5 \end{bmatrix} \]

9. \[ \begin{bmatrix} 3 \ 2 \ -1 \ 7 \\ 5 \ -8 \ 4 \ 0 ; 3 \times 4 \\ 21 \ 9 \ -13 \ 6 \end{bmatrix} \]

11. The elements in the bottom row are reversed for \( y \) and \( z \).

[\[ \begin{bmatrix} 3 \ -9 \ 5 \ 8 \\ 2 \ 11 \ 0 \ 15 \\ 6 \ 14 \ -9 \ 4 \end{bmatrix} \]

13. \((4, 3, -2)\) 15. no solution 17. \((3, -2, 1)\)

19. \( \left( \frac{2}{3}, 10, -\frac{4}{3} \right) \) 21. infinitely many solutions

23. a. \[ \begin{bmatrix} 2 \ 1 \ 0 \ 15.50 \\ 2 \ 2 \ 1 \ 37 \\ 4 \ 3 \ 2 \ 72.50 \end{bmatrix} \]

b. A movie pass costs $7, a package of microwave popcorn costs $1.50, and a DVD costs $20.
25. a. \[
\begin{bmatrix}
1 & 1 & 1 \\
0.05 & 0.1 & 0.25 \\
0 & -2 & 1
\end{bmatrix}
\begin{align*}
&= 85 \\
&= 13.25 \\
&= 0
\end{align*}
\]
b. 25 nickels, 20 dimes, 40 quarters
27. no; The number of rows is the same as the number of equations in the system. It is possible to have different numbers of equations and variables.
29. yes; You can write the rows in any order and the elements in a row in any order as long as you are consistent in the other rows.
31. a. consistent; The system has exactly one solution \((a, b, c)\).
b. consistent; The last row contains the identity \(0 = 0\), so the system has infinitely many solutions.
c. inconsistent; The last row contains the false equation \(0 = 1\), so the system has no solution.

2.3 Maintaining Mathematical Proficiency (p. 80)
33. \(x < 3\)
35. \(w \leq \frac{2}{5}\)
37. [Graph]
39. [Graph]

2.4 Vocabulary and Core Concept Check (p. 86)
1. The ordered pair must satisfy each inequality in the system.

2.4 Monitoring Progress and Modeling with Mathematics (pp. 86–88)
3. yes 5. no 7. yes
9. [Graph]
11. [Graph]
13. [Graph]
15. [Graph]
17. \(y < 2, y \geq -x, x < 2\)
19. \(y \geq -x + 1, y \leq -x + 4, y > 2x - 1\)
21. \(x < 3, x > -2, y \leq \frac{1}{2}x + 1, y \geq -x + 1\)
23. The shaded region should be below the boundary line \(y = 2x\).
25. a. \(x \geq 5, y \geq 2, 6x + 10y \leq 70\)
b. Sample answer: \((6, 2), (8, 2)\); You can purchase 6 movie passes and 2 gift cards or 8 movie passes and 2 gift cards.
27. \(x \geq 20, x \leq 50, y \geq 0.3x, y \leq 0.7x\)

2.3 Maintaining Mathematical Proficiency (p. 80)
33. \(x < 3\)
35. \(w \leq \frac{2}{5}\)
37. [Graph]
39. [Graph]

2.4 Vocabulary and Core Concept Check (p. 86)
1. The ordered pair must satisfy each inequality in the system.

2.4 Monitoring Progress and Modeling with Mathematics (pp. 86–88)
3. yes 5. no 7. yes
9. [Graph]
11. [Graph]
13. [Graph]
15. [Graph]
17. \(y < 2, y \geq -x, x < 2\)
19. \(y \geq -x + 1, y \leq -x + 4, y > 2x - 1\)
21. \(x < 3, x > -2, y \leq \frac{1}{2}x + 1, y \geq -x + 1\)
23. The shaded region should be below the boundary line \(y = 2x\).
25. a. \(x \geq 5, y \geq 2, 6x + 10y \leq 70\)
b. Sample answer: \((6, 2), (8, 2)\); You can purchase 6 movie passes and 2 gift cards or 8 movie passes and 2 gift cards.
27. \(x \geq 20, x \leq 50, y \geq 0.3x, y \leq 0.7x\)

A game that is regularly priced at $20 will cost between $6 and $14.
29. a. \(x > -3, x < 4, y > -2, y < 3\)  b. 35 square units
31. D
33. \(x \geq 8.0, x \leq 8.3, y \geq 76, y \leq 80\)

The two graphs would look similar, but the range would be \(24\frac{4}{9} \leq y \leq 26\frac{2}{3}\) when temperatures are given in degrees Celsius.
35. Sample answer: \(y \geq 5x - 2, y \leq 5x - 2, 2y \geq 10x - 4\); All three inequalities have the same boundary line.
37. no; A counterexample is \(y < x, y < x + 1, \) and \(y < x + 2\).
19. \[ x + y \geq 10, \quad x + y < 20, \quad 8x + 6y \geq 92 \]
7. The graph of \( g \) is a translation 1 unit right of the graph of \( f \).

9. The graph of \( g \) is a translation 6 units left and 2 units down of the graph of \( f \).

11. The graph of \( g \) is a translation 7 units right and 1 unit up of the graph of \( f \).

13. A; The graph has been translated 1 unit right.

15. C; The graph has been translated 1 unit right and 1 unit up.

17. The graph of \( g \) is a reflection in the \( x \)-axis of the graph of \( f \).

19. The graph of \( g \) is a vertical stretch by a factor of 3 of the graph of \( f \).

21. The graph of \( g \) is a horizontal shrink by a factor of \( \frac{1}{2} \) of the graph of \( f \).

23. The graph of \( g \) is a vertical shrink by a factor of \( \frac{1}{5} \) followed by a translation 4 units down.

25. The graph is a reflection in the \( x \)-axis, not \( y \)-axis; The graph is a reflection in the \( x \)-axis and a vertical stretch by a factor of 6, followed by a translation 4 units up of the graph of the parent quadratic function.

27. The graph of \( f \) is a vertical stretch by a factor of 3 followed by a translation 2 units left and 1 unit up of the parent quadratic function; \((-2, 1)\)

29. The graph of \( f \) is a vertical stretch by a factor of 2 followed by a reflection in the \( x \)-axis and a translation 5 units up of the parent quadratic function; \((0, 5)\)

31. \( g(x) = -4x^2 + 2; (0, 2) \)

33. \( g(x) = 8\left(\frac{1}{2}x\right)^2 - 4; (0, -4) \)

35. C; The graph is a vertical stretch by a factor of 2 followed by a translation 1 unit right and 2 units down of the parent quadratic function.

37. D; The graph is a vertical stretch by a factor of 2 and a reflection in the \( x \)-axis, followed by a translation 1 unit right and 2 units up of the parent quadratic function.

39. F; The graph is a vertical stretch by a factor of 2 and a reflection in the \( x \)-axis followed by a translation 1 unit left and 2 units down of the parent quadratic function.

41. Subtract 6 from the output; Substitute \( 2x^2 + 6x \) for \( f(x) \); Multiply the output by \(-1\); Substitute \( 2x^2 + 6x - 6 \) for \( h(x) \); Simplify.

43. \( h(x) = -0.03(x - 14)^2 + 11 \)
45. a. \( y = \frac{-5}{1089} (x - 33)^2 + 5 \)
   b. The domain is \( 0 \leq x \leq 66 \) and the range is \( 0 \leq y \leq 5 \);
   The domain represents the time the fish was in the air and the range represents the height of the fish.
   c. yes; The value changes to \( -\frac{1}{225} \). The vertex has changed but it still goes through the point \((0, 0)\), so there has been a horizontal stretch or shrink which changes the value of \( a \).

47. a. \( a = 2, h = 1, k = 6; g(x) = 2(x - 1)^2 + 6 \)
   b. \( g(x) = 2f(x - 1) + 6 \); For each function, \( a, h, \) and \( k \) are the same but the answer in part (b) does not indicate the type of function that is being translated.
   c. \( a = 2, h = 1, k = 3; g(x) = 2(x - 1)^2 + 3; \)
   \( g(x) = 2f(x - 1) + 3 \); For each function, \( a, h, \) and \( k \) are the same, but the answer in part (b) does not indicate the type of function that is being translated.
   d. Sample answer: vertex form; Writing a transformed function using function notation requires an extra step of substituting \( f(x) \) into the newly transformed function.

49. a vertical stretch by a factor of 2 or a horizontal shrink by a factor of \( \frac{1}{\sqrt{2}} \) or \( \frac{\sqrt{2}}{2} \)

3.1 Maintaining Mathematical Proficiency (p. 106)

51. (4, 4)

3.2 Vocabulary and Core Concept Check (p. 113)

1. If \( a \) is positive, then the quadratic function will have a minimum. If \( a \) is negative, then the quadratic function will have a maximum.

3.2 Monitoring Progress and Modeling with Mathematics (pp. 113–116)

3. 5. 7. 9.
31. Both functions have an axis of symmetry of $x = 2$.
33. The formula is missing the negative sign; The $x$-coordinate of the vertex is
$$x = -\frac{b}{2a} = -\frac{-24}{2(4)} = -3.$$
35. $(-25, 18.5)$; When the basketball is at its highest point, it is 25 feet from its starting point and 18.5 feet off the ground.
37. B
39. The minimum value is $-1$. The domain is all real numbers and the range is $y \geq 1$. The function is decreasing to the left of $x = 0$ and increasing to the right of $x = 0$.
41. The maximum value is 2. The domain is all real numbers and the range is $y \leq 2$. The function is increasing to the left of $x = -2$ and decreasing to the right of $x = -2$.
43. The maximum value is 15. The domain is all real numbers and the range is $y \leq 15$. The function is increasing to the left of $x = 2$ and decreasing to the right of $x = 2$.
45. The minimum value is $-18$. The domain is all real numbers and the range is $y \geq -18$. The function is decreasing to the left of $x = 3$ and increasing to the right of $x = 3$.
47. The minimum value is $-7$. The domain is all real numbers and the range is $y \geq -7$. The function is decreasing to the left of $x = 6$ and increasing to the right of $x = 6$.
49. a. 1 m  b. 3.25 m  c. The diver is ascending from 0 meters to 0.5 meters and descending from 0.5 meters until hitting the water after approximately 1.1 meters.
51. $A = w(20 - w) = -w^2 + 20w$; The maximum area is 100 square units.
61. $p = 2, q = -6$; The graph is decreasing to the left of $x = -2$ and increasing to the right of $x = -2$. 
63. \(p = 4, q = 2;\) The graph is increasing to the left of \(x = 3\) and decreasing to the right of \(x = 3.\)

65. the second kick; the first kick

67. no; Either of the points could be the axis of symmetry, or neither of the points could be the axis of symmetry. You can only determine the axis of symmetry if the \(y\)-coordinates of the two points are the same, because the axis of symmetry would lie halfway between the two points.

69. $1.75

71. All three graphs are the same; \(f(x) = x^2 + 4x + 3,\) \(g(x) = x^2 + 4x + 3\)

73. no; The vertex of the graph is \((3.25, 2.1125),\) which means the mouse cannot jump over a fence that is higher than 2.1125 feet.

75. The domain is \(0 \leq x \leq 126\) and the range is \(0 \leq y \leq 50;\) The domain represents the distance from the start of the bridge on one side of the river, and the range represents the height of the bridge.

77. no; The vertex must lie on the axis of symmetry, and \((0, 5)\) does not lie on \(x = -1.\)

79. a. about 14.1%; about 55.5 cm³/g
   b. about 13.6%; about 44.1 cm³/g
   c. The domain for hot-air popping is \(5.52 \leq x \leq 22.6,\) and the range is \(0 \leq y \leq 55.5.\) The domain for hot-oil popping is \(5.35 \leq x \leq 21.8,\) and the range is \(0 \leq y \leq 44.1.\) This means that the moisture content for the kernels can range from 5.52% to 22.6% and 5.35% to 21.8%, while the popping volume can range from 0 to 55.5 cubic centimeters per gram and 0 to 44.1 cubic centimeters per gram.

3.2 Maintaining Mathematical Proficiency (p. 116)

81. \(x = 9 + 4y\)  83. \(x = \frac{1}{2}y^2\)  85. 2  87. \(-12\)

3.3 Vocabulary and Core Concept Check (p. 124)

1. focus; directrix

3.3 Monitoring Progress and Modeling with Mathematics (pp. 124–126)

3. \(y = \frac{1}{4}x^2\)  5. \(y = -\frac{1}{8}x^2\)  7. \(y = \frac{1}{24}x^2\)  9. \(y = -\frac{1}{40}x^2\)

11. A, B and D; Each has a value for \(p\) that is negative. Substituting in a negative value for \(p\) in \(y = \frac{1}{4p}x^2\) results in a parabola that has been reflected across the \(x\)-axis.
21. Instead of a vertical axis of symmetry, the graph should have a horizontal axis of symmetry.

23. 9.5 in.; The receiver should be placed at the focus. The distance from the vertex to the focus is \( p = \frac{38}{9.5} \) in.

25. \( y = \frac{1}{32} x^2 \)  27. \( x = -\frac{1}{10} y^2 \)  29. \( x = \frac{4}{3} y^2 \)

31. \( x = \frac{4}{20} y^2 \)  33. \( y = -\frac{3}{28} x^2 \)  35. \( y = \frac{9}{4} x^2 \)

37. \( x = -\frac{1}{16} y^2 - 4 \)  39. \( y = -\frac{1}{8}(x + 1)^2 - 3 \)

41. \( y = \frac{3}{16} x^2 - 6 \)

43. The vertex is (3, 2). The focus is (3, 4). The directrix is \( y = 0 \). The axis of symmetry is \( x = 3 \). The graph is a vertical shrink by a factor of \( \frac{3}{4} \) followed by a translation 3 units right and 2 units up.

45. The vertex is (1, 3). The focus is (5, 3). The directrix is \( x = -3 \). The axis of symmetry is \( y = 3 \). The graph is a horizontal shrink by a factor of \( \frac{3}{4} \) followed by a translation 1 unit right and 3 units up.

47. The vertex is (2, -4). The focus is \( \left(\frac{23}{12}, -4\right) \). The directrix is \( x = -\frac{25}{12} \). The axis of symmetry is \( y = -4 \). The graph is a horizontal stretch by a factor of 12 followed by a reflection in the \( y \)-axis and a translation 2 units right and 4 units down.

49. \( x = \frac{1}{5.2} y^2 \); about 3.08 in.

51. As \( |p| \) increases, the graph gets wider; as \( |p| \) increases, the constant in the function gets smaller which results in a vertical shrink, making the graph wider.

53. \( y = \frac{1}{4} x^2 \)  55. \( x = -\frac{1}{4p} y^2 \)

3.4 Monitoring Progress and Modeling with Mathematics (pp. 132–134)

3. \( y = -3(x + 2)^2 + 6 \)  5. \( y = 0.06(x - 3)^2 + 2 \)

7. \( y = -\frac{1}{3}(x + 6)^2 - 12 \)  9. \( y = -4(x - 2)(x - 4) \)

11. \( y = \frac{1}{10}(x - 12)(x + 6) \)  13. \( y = 2.25(x + 16)(x + 2) \)

15. If given the \( x \)-intercepts, it is easier to write the equation in intercept form. If given the vertex, it is easier to write the equation in vertex form.

17. \( y = -16(x - 3)^2 + 150 \)  19. \( y = -0.75x^2 + 3x \)

21. The \( x \)-intercepts were substituted incorrectly.

\[ y = a(x - p)(x - q) \]

4 = \( a(3 + 1)(3 - 2) \)

\[ a = 1 \]

\[ y = (x + 1)(x - 2) \]

23. \( S(C) = 180C^2; \) 18,000 lbs

25. intercept form; The three points can be substituted into the intercept form of a quadratic equation to solve for \( a \), and then the equation can be written. This method is much shorter than writing and solving a system of three equations, although it can only be used when given the intercepts.

27. a. parabola; not a constant rate of change

b. \( y = -16x^2 + 280 \)

c. about 4.18 sec

d. The domain is \( 0 \leq t \leq 4.18 \) and represents the time the sponge was in the air. The range is \( 0 \leq h \leq 280 \) and represents the height of the sponge.

29. quadratic; The second differences are constant; \( y = -2x^2 + 42x + 470 \)

31. neither; The first and second differences are not constant.

33. a. The vertex indicates that on the 6th day, 19 people were absent, more than any other day.

b. \( y = -0.5(10 - 6)^2 + 19 \); 11 students

c. From 0 to 6 days, the average rate of change was 3 students per day. From 6 to 11 days, the average rate of change was \(-2.5\) students per day. The rate at which students were missing school was changing more rapidly as more became ill, in comparison to when the students were becoming well.

35. \( y = -16x^2 + 6x + 22 \); after about 1.24 sec; 1.375 sec

37. 155 tiles

3.4 Maintaining Mathematical Proficiency (p. 134)

39. \( (x - 2)(x - 1) \)

41. \( 5(x + 3)(x - 2) \)

Chapter 3 Review (pp. 136–138)

1. The graph is a translation 4 units left of the parent quadratic function.
2. The graph is a translation 7 units right and 2 units up of the parent quadratic function.

3. The graph is a vertical stretch by a factor of 3 followed by a reflection in the x-axis and a translation 2 units left and 1 unit down.

4. \( g(x) = \frac{9}{2}(x + 5)^2 - 2 \)

5. \( g(x) = (-x + 2)^2 - 2(-x + 2) + 3 = x^2 - 2x + 3 \)

6. The minimum value is -4; The function is decreasing to the left of \( x = 1 \) and increasing to the right of \( x = 1 \).

7. The maximum value is 35; The function is increasing to the left of \( x = 4 \) and decreasing to the right of \( x = 4 \).

8. The minimum value is -25; The function is decreasing to the left of \( x = -2 \) and increasing to the right of \( x = -2 \).

9. 2.25 in.

10. The focus is \((0, 9)\), the directrix is \( y = -9 \), and the axis of symmetry is \( x = 0 \).

11. \( x = -\frac{1}{8}y^2 \)

12. \( y = -\frac{1}{16}(x - 2)^2 + 6 \)

13. \( y = \frac{16}{81}(x - 10)^2 - 4 \)

14. \( y = -\frac{3}{5}(x + 1)(x - 5) \)

15. \( y = 4x^2 + 5x + 1 \)
16. The average rate of change from \((-4, 16)\) to the vertex is \(-6\) and the average rate of change from the vertex to \((-1, 7)\) is 3.

17. \(y = -16x^2 + 150; \text{ about } 3.06 \text{ sec}\)

**Chapter 4**

**Chapter 4 Maintaining Mathematical Proficiency (p. 143)**

1. \(3\sqrt{3}\)  2. \(-4\sqrt{7}\)  3. \(\frac{\sqrt{11}}{8}\)  4. \(7\sqrt{3}\)  5. \(\frac{3\sqrt{2}}{7}\)

6. \(-\frac{\sqrt{65}}{11}\)  7. \(-4\sqrt{5}\)  8. \(4\sqrt{2}\)  9. \((x - 6)(x + 6)\)

10. \((x - 3)(x + 3)\)  11. \((2x - 5)(2x + 5)\)  12. \((x - 11)^2\)

13. \((x + 4)^2\)  14. \((7x + 15)^2\)

15. \(a = 16 \text{ and } c = 1, \ a = 4 \text{ and } c = 4, \ a = 1 \text{ and } c = 16; 2\sqrt{ac} = 8\)

4.1 Vocabulary and Core Concept Check (p. 151)

1. Use the graph to find the \(x\)-intercepts of the function.

4.1 Monitoring Progress and Modeling with Mathematics (pp. 151–154)

3. \(x = -1 \text{ and } x = -2\)  5. \(x = 3 \text{ and } x = -3\)

7. \(x = -1\)  9. no real solution 11. no real solution

13. \(s = \pm 12\)  15. \(z = 1 \text{ and } z = 11\)  17. \(x = 1 \pm \sqrt{2}\)

19. no real solution 21. A, B, and E

23. The \(\pm\) was not used when taking the square root; \(2(x + 1)^2 + 3 = 21; 2(x + 1)^2 = 18; (x + 1)^2 = 9; x + 1 = \pm 3; x = 2 \text{ and } x = -4\)

25. a. Sample answer: \(x^2 = 16\)  b. \(x^2 = 0\)

b. Sample answer: \(x^2 = -9\)

27. \(x = -3\)  29. \(x = 6 \text{ and } x = 2\)  31. \(n = 0 \text{ and } n = 6\)

33. \(w = 12 \text{ and } w = 2\)  35. \(x = 4\)  37. \(x = 3\)

39. \(u = 0 \text{ and } u = -9\); Sample answer: factoring because the equation can be factored

41. no real solution; Sample answer: square roots because the equation can be written in the form \(u^2 = d\)

43. \(x = 6 \text{ and } x = 2\); Sample answer: square roots because the equation can be written in the form \(u^2 = d\)

45. \(x = -0.5 \text{ and } x = -2.5\); Sample answer: factoring because the equation can be factored

47. \(x = -2 \text{ and } x = -4\)  49. \(x = 3 \text{ and } x = -10\)

51. \(x = 3 \text{ and } x = -3\)  53. \(x = -11\)

55. \(f(x) = x^2 - 19x + 88\)  57. \$5.75; $1983.75

59. a. \(h(t) = -16t^2 + 188; \text{ about } 3.4 \text{ sec}\)

b. 80 ft; The log fell 80 feet between 2 and 3 seconds.

61. 0.5 ft or 6 in.

63. The 20-foot wave requires a wind speed twice as great as the wind speed required for a 5-foot wave.

65. \(x = 34.64; \text{ about } 207.84 \text{ ft, } 277.12 \text{ ft, } 173.20 \text{ ft, and } 300 \text{ ft}\)

67. the rock on Jupiter; Because the first term is negative, the height of the falling object will decrease faster as \(g\) gets larger.

69. **Flea Jump**

The vertex (6.5, 8.0) indicates that the flea’s maximum jump is 6.5 inches away from and 8.0 inches above the starting point. The zeros \(x = 13\) and \(x = 0\) indicate when the flea is on the ground.

71. you; The function does not cross the \(x\)-axis.

73. a. \(mn = 9 + m + n = 0\)

b. If \(m + n = 0\), then \(m = -n\). Substituting into the first equation results in \((-n)(n) = 9\), so \(n^2 = -9\). Because the square of a number can never be negative, you can conclude that \(m\) and \(n\) are not real numbers.

75. 60 ft

4.1 Maintaining Mathematical Proficiency (p. 154)

77. \(x^3 + 4x^2 + 6\)  79. \(-3x^3 + 7x^2 - 15x + 9\)

81. \(10x^3 - 2x^2 + 6x\)  83. \(-44x^3 + 33x^2 + 88x\)

4.2 Vocabulary and Core Concept Check (p. 160)

1. \(i = \sqrt{-1}\) and is used to write the square root of any negative number.

3. Add the real parts and the imaginary parts separately.

4.2 Monitoring Progress and Modeling with Mathematics (pp. 160–162)

5. 6i  7. \(3i\sqrt{2}\)  9. 8i  11. \(-16i\sqrt{2}\)

13. \(x = 2 \text{ and } y = 2\)  15. \(x = -2 \text{ and } y = 4\)

17. \(x = 7 \text{ and } y = -12\)  19. \(x = 6 \text{ and } y = 28\)

21. 13 + 2i  23. 9 + 11i  25. 19  27. 4 + 2i

29. \(-4 - 14i\)  31. \(-4 + 5i\)  32. \(2\sqrt{2} + 10i\)

33. \((12 + 2i)\) ohms  35. \((8 + i)\) ohms  37. \(-3 - 15i\)

39. \(-14 - 5i\)  41. 20  43. \(-27 - 36i\)

45. Distributive Property; Simplify; Definition of complex addition; Write in standard form.

47. \((6 - 7i) - (4 - 3i) = 2 - 4i\)  49. \(x = \pm 3i\)

51. \(x = \pm i\sqrt{7}\)  53. \(x = \pm 2i\sqrt{5}\)  55. \(x = \pm i\sqrt{2}\)

57. \(x = \pm 6i\)  59. \(x = \pm 3i\sqrt{3}\)  61. \(x = \pm 4i\sqrt{3}\)

63. \(i^2\) can be simplified; \(15 - 3i + 10i - 2i^2 = 15 + 7i + 2 = 17 + 7i\)

65. a. \(-8\)  b. \(-12 - 10i\)  c. \(21i\)  d. \(41 + 3i\)

e. \(-9i\)  f. \(-9 + 23i\)  g. \(14\)  h. \(14i\)

<table>
<thead>
<tr>
<th>Real numbers</th>
<th>Imaginary numbers</th>
<th>Pure imaginary numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>-8</td>
<td>12 - 10i</td>
<td>21i</td>
</tr>
<tr>
<td>14</td>
<td>14 + 3i</td>
<td>-9i</td>
</tr>
<tr>
<td>-9 + 23i</td>
<td></td>
<td>14i</td>
</tr>
</tbody>
</table>
The results of $i^n$ alternate in the pattern $i, -1, -i, 1$.


Sample answer: $3 + 2i$ and $3 - 2i$; The real parts are equal and the imaginary parts are opposites.

77. a. false; Sample answer: $(3 - 5i) + (4 + 5i) = 7$
    b. true; Sample answer: $(3i)(2i) = 6i^2 = -6$
    c. true; Sample answer: $3i = 0 + 3i$
    d. false; Sample answer: $1 + 8i$

4.2 Maintaining Mathematical Proficiency  (p. 162)

79. yes  81. no  83. $y = 2(x + 3)^2 - 3$

4.3 Vocabulary and Core Concept Check  (p. 168)

1. $\left(\frac{b^2}{2}\right)$

4.3 Monitoring Progress and Modeling with Mathematics  (pp. 168-170)

3. $x = 9$ and $x = -1$
5. $x = 9 \pm \sqrt{5}$
7. $y = 12 \pm 10i$
9. $w = -1 \pm 5\sqrt{3}$
11. 25; $(x + 5)^2$
13. 36; $(y - 6)^2$
15. $9; (x - 3)^2$
17. $\frac{25}{4}\left(z - \frac{5}{2}\right)^2$
19. $\frac{169}{4}\left(w + \frac{13}{2}\right)^2$
21. $4; x^2 + 4x + 4$
23. 36; $x^2 + 12x + 36$
25. $x = -3 \pm \sqrt{6}$
27. $x = -2 \pm \sqrt{6}$
29. $z = -\frac{9 \pm \sqrt{85}}{2}$
31. $x = -2 \pm 2i$
33. $x = -3 \pm i$
35. $x = 5 \pm 2\sqrt{7}$
37. 36 should have been added to the right side of the equation instead of 9; $4x^2 + 24x - 11 = 0$; $4(x^2 + 6x) = 11$; $4(x^2 + 6x + 9) = 11 + 36$; $4(x + 3)^2 = 47$; $(x + 3)^2 = \frac{47}{4}; x + 3 = \pm \sqrt{\frac{47}{4}}; x = -3 \pm \sqrt{\frac{47}{4}}$

41. factoring; The equation can be factored; $x = 7$ and $x = -3$
43. square roots; The equation can be written in the form $a^2 = d$; $x = -8$ and $x = 0$
45. factoring; The equation can be factored; $x = -6$
47. completing the square; The equation cannot be factored or written in the form $a^2 = d$; $x = -1 \pm \sqrt{10}$
49. square roots; The equation can be written in the form $a^2 = d$; $x = \pm 10$

1. $ \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
3. There will be two imaginary solutions.

4.4 Monitoring Progress and Modeling with Mathematics  (pp. 179-182)

5. $x = 3$ and $x = 1$
7. $x = -3 \pm i\sqrt{6}$
9. $x = 7$
11. $x = -1 \pm i\sqrt{14}$
13. $x = 5$
15. $x = \frac{3 \pm 3\sqrt{89}}{8}$
17. $z = 6 \pm \sqrt{30}$
19. 0; one real: $x = -6$
21. 400; two real: $n = 3$ and $n = -2$
23. $-135$; two imaginary: $x = \frac{5 \pm 3i\sqrt{15}}{8}$
25. 0; one real: $x = -4$
27. A
29. C; The discriminant is negative, so the graph has no $x$-intercepts.
31. A: The discriminant is positive, so the graph has two x-intercepts. The y-intercept is −9.
33. The i was left out after taking the square root; 
\[ x = \frac{-10 \pm \sqrt{-196}}{2} = \frac{-10 \pm 14i}{2} = -5 \pm 7i \]
35. Sample answer: \(a = 1\) and \(c = 5\); 
\[ x^2 + 4x + 5 = 0 \]
37. Sample answer: \(a = 2\) and \(c = 4\); 
\[ 2x^2 - 8x + 4 = 0 \]
39. Sample answer: \(a = 5\) and \(c = -5\); 
\[ 5x^2 + 10x + 5 = 0 \]
41. \(-5x^2 + 8x - 12 = 0\)  
43. \(-7x^2 + 4x - 5 = 0\)
45. \(3x^2 + 4x + 1 = 0\)
47. \(x = \pm 2\sqrt{2}\); Sample answer: square roots; The equation can be written in the form \(u^2 = d\).
49. \(x = 9\) and \(x = -3\); Sample answer: factoring; The equation can be factored.
51. \(x = 3\) and \(x = 4\); Sample answer: factoring; The equation can be factored.
53. \(x = 5 \pm i\sqrt{2}\); Sample answer: completing the square; 
Factor out 5, and \(a = 1\) and \(b\) is an even number.
55. \(x = \frac{-9 \pm \sqrt{33}}{8}\); Sample answer: Quadratic Formula; \(a \neq 1\), 
\(b\) is not an even number, the equation cannot be factored, and it cannot be easily written in the form \(u^2 = d\).
57. \(x = \frac{-1 \pm \sqrt{5}}{2}\); Sample answer: Quadratic Formula; \(b\) is not an even number, the equation cannot be factored, and it cannot be easily written in the form \(u^2 = d\).
59. \(x = 6\) 61. about 5.67 sec 63. about 0.17 sec
65. a. 
![Graph of a quadratic function with vertex at (0, 2) and x-intercepts at (-2, 0) and (2, 0).]
Both rockets start from the same height, but your friend’s rocket does not go as high and lands about a half of a second earlier.
67. a. about 0.97 sec  
68. b. the first bird; The second bird will reach the water after about 0.98 second.
69. 3.5 ft
71. a. \(a = 6, x = -3, y = 5\), and \(x = -2\)  
73. Add the solutions to get \(-\frac{b}{a}\), then divide the result by 2 to get \(-\frac{b}{2a}\); Because it is symmetric, the vertex of a parabola is in the middle of the two x-intercepts and the x-coordinate of the vertex is \(-\frac{b}{2a}\).
75. If \(x = 3i\) and \(x = -2i\) are solutions, then the equation can be written as \(a(x - 3i)(x + 2i) = ax^2 - aix + 6a\). \(a\) and \(ai\) cannot both be real numbers.

4.4 Maintaining Mathematical Proficiency (p. 182)
77. \((4, 5)\) 79. no solution

4.5 Vocabulary and Core Concept Check (p. 188)
1. There could be no solution, one solution, or two solutions.

4.5 Monitoring Progress and Modeling with Mathematics (pp. 188–190)
3. \((0, 2)\) and \((-2, 0)\) 5. no solution 7. \((-4, 2)\)
9. \((1, 1)\) and \((3, 1)\) 11. about 32.5 in. 13. no solution
15. \((2, 3)\) and \((-2, 3)\) 17. \((2, 7)\) and \((0, 5)\)
19. no solution
21. about \((-4.65, -4.71)\) and about \((0.65, -15.29)\)
23. \((-4, -4)\) and \((-6, -4)\) 25. \((7, 0)\) and \((0, 7)\)
27. no solution
29. The terms that were added were not like terms; 
\[0 = -2x^2 + 34x - 140; x = 7\ or\ x = 10\]
31. \((0, -1)\); Sample answer: elimination because the equations are arranged with like terms in the same column
33. about \((-11.31, 10)\) and about \((5.31, 10)\); Sample answer: substitution because the second equation can be substituted into the first equation
35. \((3, 3)\) and \((5, 3)\); Sample answer: graphing because substitution and elimination would require more steps in this case
37. \(x = 0\) 39. \(x \approx 0.63\) and \(x \approx 2.37\)
41. \(x = 2\) and \(x = 3\)
43. The graphs intersect at the vertex of the quadratic function.
45. \(d = 0.8t; d = 2.5t^2; 0.32\ min\)
47. no solution: \( m = 1 \); one solution: \( m = 0 \); two solutions: \( m = -1 \)

49. Sample answer: graphing and Quadratic Formula; graphing because it requires less time and steps than using the Quadratic Formula in this case

51. a. no solution, one solution, two solutions, three solutions, or four solutions

53. a. circle: \( x^2 + y^2 = 1 \), Oak Lane: \( y = -\frac{1}{2}x + \frac{5}{2} \)

b. (−0.6, 0.8) and (0.8, 0.6)

c. about 1.41 mi
4.5 Maintaining Mathematical Proficiency (p. 190)

55. \( x > 3 \)

57. \( x \leq -4 \)

59. \( y < x - 2 \)

4.6 Vocabulary and Core Concept Check (p. 196)

1. The graph of a quadratic inequality in one variable consists of a number line, but the graph of a quadratic inequality in two variables consists of both the x- and y-axis.

4.6 Monitoring Progress and Modeling with Mathematics (pp. 196–198)

3. C; The x-intercepts are \( x = -1 \) and \( x = -3 \). The test point \((-2, 5)\) does not satisfy the inequality.

5. B; The x-intercepts are \( x = 1 \) and \( x = 3 \). The test point \((2, 5)\) does not satisfy the inequality.

7.

9.

11.

13.

21.

23.

25.

Sample answer: \((0, \frac{1}{2})\) and \((\frac{1}{2}, 1)\)

Sample answer: \((3, -2)\) and \((2, -5)\)

Sample answer: \((0, 0)\) and \((1, 2)\)

27. \(-\frac{5}{2} \leq x < \frac{5}{3}\)  29. \(x \leq 4\) or \(x \geq 7\)  31. \(-0.5 \leq x \leq 3\)

33. \(x < -2 \) or \(x > 4\)  35. \(0.38 < x < 2.62\)

37. \(x < -7 \) or \(x > -1\)  39. \(-2 \leq x \leq \frac{4}{3}\)

41. about \(x \leq -6.87\) or \(x \geq 0.87\)

43. a. \(x_1 < x_2\)  b. \(x < x_1\) or \(x > x_2\)  c. \(x_1 < x < x_2\)

45. about 55 m from the left pylon to about 447 m from the left pylon

47. a. \(0.0051x^2 - 0.319x + 15 < 0.005x^2 - 0.23x + 22\), \(16 \leq x \leq 70\)

b. \(A(x) < V(x)\) for \(16 \leq x \leq 70\); Graph the inequalities only on \(16 \leq x \leq 70\). \(A(x)\) is always greater than \(V(x)\).
c. The driver would react more quickly to the light changing from green to yellow; The reaction time to visual stimuli is always less.

49. \(0.00170x^2 + 0.145x + 2.35 > 10, 0 \leq x \leq 40;\) after about 37 days; Because \(L(x)\) is a parabola, \(L(x) = 10\) has two solutions. Because the \(x\)-value must be positive, the domain requires that the negative solution be rejected.

51. a. \(\frac{32}{3} \approx 10.67\) square units  
b. \(\frac{256}{3} \approx 85.33\) square units

53. a. yes; The points on the parabola that are exactly 11 feet high are \((6,11)\) and \((14,11)\). Because these points are 8 feet apart, there is enough room for a 7-foot wide truck.

b. 8 ft  
c. about 11.2 ft

4.6 Maintaining Mathematical Proficiency  

55.

57. The maximum value is \(-1\); The function is increasing to the left of \(x = -3\) and decreasing to the right of \(x = -3\).

59. The maximum value is 25; The function is increasing to the left of \(x = -2\) and decreasing to the right of \(x = -2\).

Chapter 4 Review  

1. \(x = 4\) and \(x = -2\)  
2. \(x = \pm 2\)  
3. \(x = 2\) and \(x = -8\)  
4. \(x = 6\) and \(x = 2.5\)  
5. \((2x + 18)(2x + 35) = 1260; x = 5; 28\) ft by 45 ft

6. \(x = 9\) and \(y = -3\)  
7. \(5 - 3i\)  
8. \(11 + 10i\)

9. \(-62 + 11i\)  
10. \(x = \pm i\sqrt{3}\)  
11. \(x = \pm 4i\)

12. 148 ft  
13. \(x = -8 \pm 4\sqrt{7}\)  
14. \(x = -4 \pm \frac{3i}{2}\)

15. \(x = 3 \pm 3\sqrt{2}\)  
16. \(y = (x - 1)^2 + 19; (1,19)\)

17. \(x = \frac{5 \pm \sqrt{17}}{2}\)  
18. \(x = 0.5\) and \(x = -3\)

19. \(x = \frac{6 \pm i\sqrt{3}}{3}\)  
20. 0; one real solution: \(x = -3\)

21. 40; two real solutions: \(x = 1 \pm \sqrt{10}\)

22. 16; two real solutions: \(x = -5\) and \(x = -1\)

23. \((-2,6)\) and \((1,0)\); Sample answer: substitution because both equations are already solved for \(y\)

24. \((4,5)\); Sample answer: elimination because adding the like terms eliminates \(y\)

25. about \((-0.32, 1.97)\) and \((0.92, -1.77)\); substitution because elimination is not a possibility with no like terms

26. about \((-0.14, -1.77)\) and \((1.77, -1.53)\)
32. \( y > 2x^2 - x + 5 \)

33. \( x \leq -5 \) or \( x \geq 4 \)
34. \( x < -7 \) or \( x > -3 \)
35. \( \frac{2}{3} \leq x \leq 1 \)

Chapter 5

Chapter 5 Maintaining Mathematical Proficiency (p. 207)

1. \( 2x \)
2. \( 4m + 3 \)
3. \( y + 6 \)
4. \( x + 4 \)
5. \( z - 4 \)
6. \( 5x \)
7. \( 64 \text{ in}^3 \)
8. \( \frac{32\pi}{3} \text{ ft}^3 \approx 33.51 \text{ ft}^3 \)
9. 88 ft²
10. \( 48\pi \text{ cm}^2 \approx 150.80 \text{ cm}^2 \)
11. no; If the volume of a cube is doubled, the side length is increased by a factor of \( \sqrt[3]{2} \).

5.1 Vocabulary and Core Concept Check (p. 214)

1. The end behavior describes the behavior of a graph as \( x \) approaches positive infinity and negative infinity.

5.1 Monitoring Progress and Modeling with Mathematics (pp. 214–216)

3. polynomial function; \( f(x) = 5x^3 - 6x^2 - 3x + 2; \) degree: \( 3 \) (cubic), leading coefficient: \( 5 \)
5. not a polynomial function
7. polynomial function; \( h(x) = -\sqrt{7}x^4 + 8x^3 + \frac{5}{3}x^2 + x - \frac{1}{2}; \) degree 4 (quartic), leading coefficient: \( -\sqrt{7} \)
9. The function is not in standard form so the wrong term was used to classify the function; \( f \) is a polynomial function. The degree is 4 and \( f \) is a quartic function. The leading coefficient is \( -7 \).
11. \( h(-2) = -46 \)
13. \( g(8) = -43 \)
15. \( p\left(\frac{1}{2}\right) = \frac{45}{4} \)
17. \( h(x) \to -\infty \) as \( x \to -\infty \) and \( h(x) \to -\infty \) as \( x \to \infty \)
19. \( f(x) \to \infty \) as \( x \to -\infty \) and \( f(x) \to \infty \) as \( x \to \infty \)
21. The degree of the function is odd and the leading coefficient is negative.
23. polynomial function; \( f(x) = -4x^4 + \frac{3}{2}x^3 + \sqrt{2}x^2 + 4x - 6; \) degree: \( 4 \) (quartic), leading coefficient: \( -4 \)
From 1980 to 2007 the number of open drive-in theaters decreased. Around the year 1995, the rate of decrease began to level off.

b. 1980 to 1995: about −119.6, 1995–2007: about −19.2; About 120 drive-in movie theaters closed each year on average from 1980–1995. From 1995 to 2007, drive-in movie theaters were closing at a much lower rate, with about 20 theaters closing each year.

c. Because the graph declines so sharply in the years leading up to 1980, it is most likely not accurate. The model may be valid for a few years before 1980, but in the long run, decline may not be reasonable. After 2007, the number of drive-in movie theaters declines sharply and soon becomes negative. Because negative values do not make sense given the context, the model cannot be used for years after 2007.

43. Because the graph of g is a reflection of the graph of f in the y-axis, the end behavior would be opposite; g(x) → −∞ as x → −∞ and g(x) → ∞ as x → ∞.

45. The viewing window is appropriate if it shows the end behavior of the graph as x → ∞ and x → −∞.

47. a. 

y = x, y = x³, and y = x⁵ are all symmetric with respect to the origin.

y = x², y = x⁴, and y = x⁶ are all symmetric with respect to the y-axis.

b. The graph of y = x¹⁰ will be symmetric with respect to the y-axis. The graph of y = x¹¹ will be symmetric with respect to the origin; The exponent is even. The exponent is odd.

49. f(−5) = −480; Substituting the two given points into the function results in the system of equations 2 + b + c − 5 = 0 and 16 + 4b + 2c − 5 = 3. Solving for b and c gives f(x) = 2x³ − 7x² + 10x − 5.

5.1 Maintaining Mathematical Proficiency (p. 216)
51. −2x² + 3xy + y²
52. 12kz − 4kw
53. −x³y² + 3x²y + 13xy − 12x + 9

5.2 Vocabulary and Core Concept Check (p. 222)
1. The binomials could be multiplied in a horizontal format or a vertical format. The patterns from Pascal’s Triangle could also be used.

5.2 Monitoring Progress and Modeling with Mathematics (pp. 222–224)
3. x² + x + 1
5. 12x² + 5x⁴ − 3x³ + 6x − 4
7. 7x⁶ + 7x⁵ + 8x³ − 9x² + 11x − 5
9. −2x³ − 14x² + 7x − 4
11. 5x⁶ − 7x⁵ + 6x⁴ + 9x³ + 7
13. −x⁵ + 7x³ + 11x² + 10x − 4
15. P = 47.7t² + 678.5t + 17,667.4; The constant term represents the total number of people attending degree-granting institutions at time t = 0.
17. 35x⁵ + 21x³ + 7x³
19. −10x⁵ + 23x² − 24x + 18
21. x⁴ − 5x³ − 3x² + 22x + 20
23. 3x⁵ − 6x⁴ − 6x³ + 25x² − 23x + 7
25. The negative was not distributed through the entire second set of parentheses; (x² − 3x + 4) − (x³ + 7x − 2) = x² − 3x + 4 − x³ − 7x + 2 = −x³ + x² − 10x + 6
27. x³ + 3x² − 10x − 24
29. 12x³ − 29x² + 7x + 6
31. −24x³ + 86x² − 57x − 20
33. (a + b)(a − b) = a² − ab − ab + b² = a² − b²;
Sample answer: 24 • 16 = (20 + 4)(20 − 4) = 20² − 4² = 400 − 16 = 384
35. x² − 81
37. 9c² − 30c + 25
39. 49h² + 56h + 16
41. 4k³ + 72k² + 216k + 216
43. 8t³ + 48t² + 96t + 64
45. 16a⁴ + 96a³ + 216a² − 216a + 81
47. y⁶z⁵ + 5y⁴z⁵ + 10y³z⁴ + 10yz³ + 5yz + 1
49. 9a⁸ + 66a⁶b + 97a⁴b⁴ + 88a²b⁶ + 16b⁸; Sample answer: Pascal’s Triangle; Use Pascal’s Triangle to expand the two binomials. Multiply the results vertically to find your final product.
51. 2x³ + 10x² + 14x + 6
53. a. 5000(1 + r)³ + 1000(1 + r)² + 4000(1 + r)
b. 7000r³ + 25,000r² + 34,000r + 16,000; 7000 is the total amount of money that gained interest for three years, 25,000 is the total amount of money that gained interest for two years, 34,000 is the total amount of money that gained interest for one year, and 16,000 is the total amount of money invested.
c. About $17,763.38
55. no: The sum of (x + 3) and (x − 3) is 2x, a monomial. The product of (x + 3) and (x − 3) is x² − 9, a binomial.
57. equivalent; They produce the same graph.
59. not equivalent; Although they appear to produce the same graph, the table of values shows they are off by a constant of 1.
63. a. 5 b. 5 c. 9
   d. $g(x) + h(x)$ has degree $m$, $g(x) - h(x)$ has degree $m$. $g(x) \cdot h(x)$ has degree $(m + n)$.

65. a. $(x^2 - y^2)^2 + (2xy)^2 = (x^2 + y^2)^2$
   b. The Pythagorean triple is 11, 60, and 61.
   c. $121 + 3600 = 3721$

5.3 Maintaining Mathematical Proficiency (p. 224)

5.3 Vocabulary and Core Concept Check (p. 229)

1. To evaluate the function $f(x) = x^3 - 2x + 4$ when $x = 3$, synthetic division can be used to divide $f(x)$ by the factor $x - 3$. The remainder is the value of $f(3)$. So, $f(3) = 25$.
   Sample answer: $3 | 1 0 -2 4$

5.3 Monitoring Progress and Modeling with Mathematics (p. 229–230)

5. $x + 5 + \frac{3}{x - 4}$
   7. $x + 1 + \frac{2x + 3}{x^2 - 1}$
   9. $5x^2 - 12x + 37 + \frac{-122x + 109}{x^2 + 2x - 4}$
   11. $x + 12 + \frac{49}{x - 4}$
   13. $2x - 11 + \frac{62}{x + 5}$
   15. $x^3 + \frac{3}{x - 3}$
   17. $x^3 + x^2 - 2x + 1 + \frac{6}{x - 6}$
   19. D; $(2)^2 + (2) - 3 = 3$ so the remainder must be 3.
   21. C; $(2)^2 - (2) + 3 = 3$ so the remainder must be 5.
   23. The quotient should be one degree less than the dividend. $x^4 - 5x + 3 = x^3 - x^2 + 2x - 1 + \frac{1}{x - 2}$
   25. $f(-1) = 37$ 27. $f(2) = 11$ 29. $f(6) = 181$
   31. $f(3) = 115$
   33. no; The Remainder Theorem states that $f(a) = 15$.

5.4 Monitoring Progress and Modeling with Mathematics (pp. 236–238)

5. $x(x - 6)(x + 4)$ 7. $3p^3(p - 8)(p + 8)$
   9. $q^4(2q - 3)(q + 6)$ 11. $w^6(5w - 2)(2w - 3)$
   13. $(x + 4)(x^2 - 4x + 16)$ 15. $(g - 7)(g^2 + 7g + 49)$
   17. $3h^6(h^2 - 4)(h^2 + 4h + 16)$
   19. $2r^4(2r + 5)(4r^2 - 10r + 125)$
   21. $x^2 + 9$ is not a factorable binomial because it is not the difference of two squares; $3x^2 + 27x = 3(x^2 + 9)$
   23. $(y^2 + 6)(y - 5)$ 25. $(3a^2 + 8)(a + 6)$
   27. $(x - 2)(x + 2)(x - 8)$ 29. $(q + 2)(q + 5)(q^2 - 2q + 4)$
   31. $(7k^2 + 3)(7k^2 - 3)$ 33. $(c^2 + 5)(c^2 + 4)$
   35. $(4c^2 + 9)(2c + 3)(2c - 3)$ 37. $3r^3(r^2 + 5)(r^3 - 4)$

5.4 Vocabulary and Core Concept Check (p. 236)

1. quadratic; $3x^2$
   3. It is written as a product of unfactorable polynomials with integer coefficients.
5.5 Monitoring Progress and Modeling with Mathematics (pp. 246–248)

3. \( z = -3, z = 0, \text{ and } z = 4 \)  
5. \( x = 0 \) and \( x = 1 \)  
7. \( w = 0 \) and \( w = \pm \sqrt{10} \approx \pm 3.16 \)  
9. \( c = 0, c = 3, \text{ and } c = \pm \sqrt{6} \approx \pm 2.45 \)  
11. \( n = -4 \)  
13. \( x = -3, x = 0, \) and \( x = 2 \)

77. \( x = 6 \) and \( x = -5 \)  
79. \( x = \frac{3}{2} \) and \( x = 2 \)  
81. \( x = 18 \) and \( x = -6 \)  
83. \( x = -3 \) and \( x = -7 \)

5.4 Maintaining Mathematical Proficiency (p. 238)

77. \( x = 6 \) and \( x = -5 \)  
79. \( x = \frac{3}{2} \) and \( x = 2 \)  
81. \( x = 18 \) and \( x = -6 \)  
83. \( x = -3 \) and \( x = -7 \)

5.5 Vocabulary and Core Concept Check (p. 246)

1. constant term; leading coefficient

5.5 Selected Answers

65. a. no; \( 7z^4(2z + 3)(z - 2) \)  
b. no; \( n(2 - n)(n + 6)(3n - 11) \)  
c. yes

67. 0.7 million

69. Sample answer: Factor Theorem and synthetic division; Calculations without a calculator are easier with this method because the values are lesser.

71. \( k = 22 \)

73. a. \( (c - d)(c + d)(7a + b) \)  
b. \( (x^n - 1)(x^n - 1) \)  
c. \( (a^3 - b^2)(ab + 1)^2 \)

75. a. \( (x + 3)^2 + y^2 = 5^2 \); The center of the circle is \((-3, 0)\) and the radius is 5.  
b. \( (x - 2)^2 + y^2 = 3^2 \); The center of the circle is \((2, 0)\) and the radius is 3.  
c. \( (x - 4)^2 + (y + 1)^2 = 6^2 \); The center of the circle is \((4, -1)\) and the radius is 6.

5.5 Maintaining Mathematical Proficiency (p. 238)

77. \( x = 6 \) and \( x = -5 \)  
79. \( x = \frac{3}{2} \) and \( x = 2 \)  
81. \( x = 18 \) and \( x = -6 \)  
83. \( x = -3 \) and \( x = -7 \)

5.5 Vocabulary and Core Concept Check (p. 246)

1. constant term; leading coefficient

21. C

23. The ± was not included with each factor; \( \pm 1, \pm 3, \pm 5, \pm 9, \pm 15, \pm 45 \)

25. \( x = -5, x = 1, \) and \( x = 3 \)  
27. \( x = -1, x = 5, \) and \( x = 6 \)  
29. \( x = -3, x = 4, \) and \( x = 5 \)
31. \( x = -4, x = -0.5, \) and \( x = 6 \)  
33. \(-5, 3, \) and \(4\
35. \(-5, -3, \) and \(-2\)  
37. \(-4, 1.5, \) and \(3\)
39. \(1, -1 + \sqrt{17} \) \(\frac{1.56, \) and \(-1 - \sqrt{17} \) \(-2.56) 
41. \( f(x) = x^3 - 7x^2 + 36 \)  
43. \( f(x) = x^3 - 10x - 12 \) 
45. \( f(x) = x^4 - 32x^2 + 24x \) 
47. \( x = -3, x = 3, \) and \( x = 4\)  

Sample answer: graphing; The equation has three real solutions, all which can be found by graphing to find the x-intercepts.

49. \( 4 \text{ cm by 4 cm by 7 cm} \) 
51. \( \text{The block is 3 meters high, 21 meters long, and 15 meters wide.}\)
53. a. \(-20r^3 + 252r^2 - 280r - 2400 = 0\)  
b. \(1, 2, 3, 4, 5, 6, 8, 10\)  
c. \(t = 5\) years and \(t = 10\) years
55. The length should be \(8\) feet, the width should be \(4\) feet, and the height should be \(4\) feet.
57. a. \(k = 60\)  
b. \(k = 33\)  
c. \(k = 6\)
59. \(x = 1\)  
61. \(x = 2\)
63. The height of each ramp is \(\frac{5}{2}\) feet and the width of each ramp is \(5\) feet. The left ramp is to be \(24\) feet in length while the right ramp is to be \(12\) feet in length.
65. \(rs; \) Each factor of \(a_0\) can be written as the numerator with each factor of \(a_n\) as the denominator, creating \(r \times s\) factors.

5.5 Maintaining Mathematical Proficiency (p. 248)
67. not a polynomial function
69. not a polynomial function; The term \(\sqrt[3]{x}\) has an exponent that is not a whole number.
71. \(x = \pm 3i\) 
73. \(x = \pm \sqrt[3]{2} \) 

5.6 Vocabulary and Core Concept Check (p. 254)
1. complex conjugates

5.6 Monitoring Progress and Modeling with Mathematics (pp. 254–256)
3. \(4\)  
5. \(6\)  
6. \(7\)  
7. \(-1, 1, 2, \) and \(4\)
9. \(-2, -2, 1, \) and \(3\)
11. \(-2, -1, 2, \) and \(3\)
13. \(-3, -1, 2i, \) and \(-2i\)
15. \(-4, -1, 2, i\sqrt{2}, \) and \(-i\sqrt{2}\)
17. \(2; \) The graph shows \(2\) real zeros, so the remaining zeros must be imaginary.
19. \(2; \) The graph shows no real zeros, so all of the zeros must be imaginary.
21. \(f(x) = x^3 + 4x^2 - 7x - 10\)
23. \(f(x) = x^3 - 11x^2 + 41x - 51\)
25. \(f(x) = x^3 - 4x^2 - 5x + 20\)
27. \(f(x) = x^5 - 8x^4 + 23x^3 - 32x^2 + 22x - 4\)
29. The conjugate of the given imaginary zeros was not included.
\[ f(x) = (x - 2)[(x - 1 + i)][x - (1 - i)] \]
\[= (x - 2)[(x - 1) - i][(x - 1) + i]\]
\[= (x - 2)[x^2 - 1 - i^2]\]
\[= (x - 2)(x^2 - 2x + 1 - (-1)]\]
\[= (x - 2)(x^2 - 2x + 2)\]
\[= x^3 - 2x^2 + 2x - 2x^2 + 4x - 4\]
\[= x^3 - 4x^2 + 6x - 4\]
31. Sample answer: \(y = x^6 - 4x^4 - x^2 + 4; \)
\[y = (x - 1)(x - 1)(x - 1)(x - i)(x + i)\]
\[= (x^2 - 1)(x^2 - 4)(x + 1)\]
\[= (x^4 - 5x^2 + 4)(x^3 + 1)\]
\[= x^6 + x^4 - 5x^2 + 4x^2 + 4\]
\[= x^6 - 4x^4 - x^2 + 4\]
33. \(\begin{array}{cccc}
\text{Positive real zeros} & \text{Negative real zeros} & \text{Imaginary zeros} & \text{Total zeros} \\
1 & 1 & 2 & 4 \\
35. \(\begin{array}{cccc}
\text{Positive real zeros} & \text{Negative real zeros} & \text{Imaginary zeros} & \text{Total zeros} \\
2 & 1 & 0 & 3 \\
0 & 1 & 2 & 3 \\
37. \(\begin{array}{cccc}
\text{Positive real zeros} & \text{Negative real zeros} & \text{Imaginary zeros} & \text{Total zeros} \\
3 & 2 & 0 & 5 \\
3 & 0 & 2 & 5 \\
1 & 2 & 2 & 5 \\
1 & 0 & 4 & 5 \\
39. \(\begin{array}{cccc}
\text{Positive real zeros} & \text{Negative real zeros} & \text{Imaginary zeros} & \text{Total zeros} \\
3 & 3 & 0 & 6 \\
3 & 1 & 2 & 6 \\
1 & 3 & 2 & 6 \\
1 & 1 & 4 & 6 \\
41. \(C; \) There are three sign changes in the coefficients of \(f(-x). \)
So, the number of negative real zeros is two or zero, not four.
43. in the year 1957  
45. in the 3rd year  
47. \(x = 4.2577\) 
49. no; The Fundamental Theorem of Algebra applies to functions of degree greater than zero. Because the function \(f(x) = 2\) is equivalent to \(f(x) = 2^0, \) it has degree 0, and does not fall under the Fundamental Theorem of Algebra.
57. The function is a vertical stretch by a factor of 5 followed by a translation 4 units left of the parent quadratic function.

59. \( g(x) = \left| \frac{1}{2}x + 1 \right| - 3 \)

5.7 Vocabulary and Core Concept Check (p. 261)

1. horizontal

5.7 Monitoring Progress and Modeling with Mathematics (pp. 261–262)

3. The graph of \( g \) is a translation 3 units up of the graph of \( f \).

5. The graph of \( g \) is a translation 1 unit left and 4 units down of the graph of \( f \).

5.6 Maintaining Mathematical Proficiency (p. 256)

55. The function is a translation 4 units right and 6 units up of the parent quadratic function.
13. The graph of $g$ is a vertical stretch by a factor of 5 followed by a translation 1 unit up of the graph of $f$.

15. The graph of $g$ is a vertical shrink by a factor of $\frac{3}{4}$ followed by a translation 4 units left of the graph of $f$.

17. $g(x) = (x + 2)^3 + 1$

19. $g(x) = -x^4 + x^2 - 3$

21. The graph has been translated horizontally to the right 2 units instead of to the left 2 units.

23. $g(x) = (-x + 3)^3 - 6$

25. $g(x) = -27x^3 - 18x^2 + 7$

27. $W(x) = 27x^3 - 12x$; $W(5) = 3315$; When $x$ is 5 yards, the volume of the pyramid is 3315 cubic feet.

29. Sample answer: If the function is translated up and then reflected in the $x$-axis, the order is important; if the function is translated left and then reflected in the $x$-axis, the order is not important; reflecting a graph in the $x$-axis does not affect its $x$-coordinate, but it does affect its $y$-coordinate. So, the order is only important if the other translation is in the $y$-axis.

31. a. 0 m, 4 m, and 7 m
   b. $g(x) = -\frac{2}{3}(x - 2)(x - 6)^2(x - 9)$

33. $V(x) = 3\pi x^2(x + 3)$; $W(x) = \frac{\pi}{3}x(\frac{1}{3}x + 3)$:
   $W(3) = 12\pi \approx 37.70$; When $x$ is 3 feet, the volume of the cone is about 37.70 cubic yards.

5.7 Maintaining Mathematical Proficiency (p. 262)

35. The maximum value is 4; The domain is all real numbers and the range is $y \leq 4$. The function is increasing to the left of $x = 0$ and decreasing to the right of $x = 0$.

37. The maximum value is 9; The domain is all real numbers and the range is $y \leq 9$. The function is increasing to the left of $x = -5$ and decreasing to the right of $x = -5$.

39. The maximum value is 1; The domain is all real numbers and the range is $y \leq 1$. The function is increasing to the left of $x = 1$ and decreasing to the right of $x = 1$.

5.8 Vocabulary and Core Concept Check (p. 268)

1. turning

5.8 Monitoring Progress and Modeling with Mathematics (pp. 268–270)

3. A 5. B

7. 

9.
25. \[ y = x^2 - 4x + 4 \]

The x-intercepts of the graph are \( x \approx -1.88, x = 0, \) and \( x \approx 1.53. \) The function has a local maximum at \((0, 0)\) and local minimum at \((-1.30, -3.51)\) and \((1.13, -1.07)\); The function is increasing when \(-1.30 < x < 0\) and \( x > 1.13 \) and is decreasing when \( x < -1.30\) and \( 0 < x < 1.13.\)

27. \[ y = 2x^2 - 4x + 2 \]

The x-intercept of the graph is \( x \approx -2.46. \) The function has a local maximum at \((-1.15, 4.04)\) and a local minimum at \((1.15, 0.96)\); The function is increasing when \( x < -1.15\) and \( x > 1.15 \) and is decreasing when \(-1.15 < x < 1.15.\)

29. \[ y = x^2 - 4x + 4 \]

The x-intercepts of the graph are \( x \approx -2.10, x \approx -0.23, \) and \( x \approx 1.97. \) The function has a local maximum at \((-1.46, 18.45)\) and a local minimum at \((1.25, -19.07)\); The function is increasing when \( x < -1.46\) and \( x > 1.25\) and is decreasing when \(-1.46 < x < 1.25.\)

33. \[ y = 3x^2 - 4x + 2 \]

The x-intercepts of the graph are \( x = 1, x = 3, \) and \( x = 2. \) \((1, 0)\) and \((3, 0)\) are local maximums, and \((2, -2)\) is a local minimum. The real zeros are 1 and 3. The function is of at least degree 3.

35. \[ y = 3x^2 - 4x + 2 \]

The x-intercepts of the graph are \( x = -1.25, x = -10.65; \) \(-1.25, -10.65\) is a local minimum; The real zeros are \(-2.07\) and \(1.78. \) The function is of at least degree 4.

39. odd 41. even 43. neither 45. even
5.8 Maintaining Mathematical Proficiency (p. 270)
57. quadratic; The second differences are constant.
5.9 Vocabulary and Core Concept Check (p. 275)
1. finite differences

5.9 Monitoring Progress and Modeling with Mathematics (pp. 275–276)
3. $f(x) = (x + 1)(x - 1)(x - 2)$
5. $f(x) = \frac{1}{2}(x + 5)(x - 1)(x - 4)$
7. $f(x) = \frac{x}{3} + 4x^2 - \frac{3}{2}x - 4$
9. $f(x) = -3x^4 - 5x^3 + 9x^2 + 3x - 1$
11. $f(x) = x^4 - 15x^3 + 81x^2 - 183x + 142$

13. The sign in each parentheses is wrong. The x-intercepts should have been subtracted form zero, not added.

15. Sample answer:
$y = (x - 3)(x - 4)(x + 1)$,
$y = 3(x - 3)(x - 4)(x - 1)$,
$y = \frac{3}{2}(x - 3)(x - 4)(x + 4)$;
$y = a(x - 3)(x - 4)(x - c)$
$6 = a(2 - 3)(2 - 4)(2 - c)$
$6 = 2a(2 - c)$
$3 = a(2 - c)$
$\frac{3}{2} - c = a$

Any combination of $a$ and $c$ that fit the equation will contain these points.

17. $0.002x^2 + 0.601x - 2.493$; about 15.9 mph
19. $d = \frac{1}{3}x^2 - \frac{1}{3}x$; 35
21. With real-life data sets, the numbers rarely fit a model perfectly. Because of this, the differences are rarely constant.

23. C, A, B, D

5.9 Maintaining Mathematical Proficiency (p. 276)

25. $x = \pm 6$
27. $x = 3 \pm 2\sqrt{3}$
29. $x = 1$ and $x = -2.5$

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

Chapter 5 Review (pp. 278–282)
1. polynomial function; $h(x) = -15x^3 - x^2 + 2x^2$; It has degree 7 and a leading coefficient of $-15$.
2. not a polynomial
3. 

5. 

6. $4x^3 - 4x^2 - 4x - 8$
7. $3x^4 + 3x^3 - x^2 - 3x + 15$
8. $2x^2 + 11x + 1$
9. $2y^3 + 10y^2 + 5y - 21$
10. $8m^2 + 12mn + 6mn^2 + n^4$
11. $s^4 + 3s^2 - 10s - 24$
12. $m^4 + 16m^3 + 96m^2 + 256m + 256$
13. $243x^3 + 810x^2 + 1080x + 720x^2 + 240x + 32$
14. $z^6 + 6z^5 + 15z^4 + 20z^3 + 15z^2 + 6z + 1$
15. $x - 1 + \frac{4x - 3}{x^2 + 2x + 1}$
16. $x^2 + 2x - 10 + \frac{7x + 43}{x^3 + x + 4}$
17. $x^3 - 4x^2 + 15x - 60 + \frac{243}{x + 4}$
18. $g(5) = 546$
19. $8(2x - 1)(4x^2 + 2x + 1)$
20. $2z(z^2 - 5)(z - 1)(z + 1)$
21. $(a - 2)(a + 2)(2a - 7)$
22. 

23. $x = -4$, $x = 2$, and $x = 3$
24. $x = -4$, $x = 3$, and $x = 2$
25. $f(x) = x^3 - 5x^2 + 5x - 1$
26. $f(x) = x^4 - 5x^3 + x^2 + 25x - 30$
27. $f(x) = x^4 - 9x^3 + 11x^2 + 51x - 30$
28. The length is 6 inches, the width is 2 inches, and the height is 20 inches; When $f(\ell - 4)(3\ell + 2) = 240$, $\ell = 6$
29. $f(x) = x^3 - 5x^2 + 11x - 15$
30. $f(x) = x^4 - x^3 + 14x^2 - 16x - 32$
31. $f(x) = x^4 + 7x^3 + 6x^2 - 4x + 80$

32. | Positive real zeros | Negative real zeros | Imaginary zeros | Total zeros |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
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</tbody>
</table>
33. The graph of g is a reflection in the y-axis followed by a translation 2 units up of the graph of f.

34. The graph of g is a reflection in the x-axis followed by a translation 9 units left of the graph of f.

35. The x-intercept of the graph is $x = -1.68$. The function has a local maximum at $(0, -1)$ and a local minimum at $(-1, -2)$; The function is increasing when $-1 < x < 0$ and decreasing when $x < 1$ and $x > 0$.

36. $g(x) = \frac{1}{1064}(x - 3)^3 + \frac{3}{4}(x - 3) - 5$

37. $g(x) = x^3 + 2x^3 - 7$

38. The x-intercepts of the graph are $x = 0.25$ and $x = 1.34$. The function has a local maximum at $(-1.13, 7.06)$ and local minimums at $(-2, 6)$ and $(0.88, -3.17)$; The function is increasing when $-2 < x < -1.13$ and $x > 0.88$ and is decreasing when $x < -2$ and $-1.13 < x < 0.88$.

39. $f(x) = \frac{3}{16}(x + 4)(x - 4)(x - 2)$

40. $f(x) = 2x^3 - 7x^2 - 6x$

41. $f(x) = \frac{8w^9}{x^6}$

42. $f(x) = \frac{m^{10}}{x^4}$

43. $y = 2 - 4x$

44. $y = 3 + 3x$

45. $y = \frac{13}{7}x + \frac{9}{2}$

46. $y = \frac{5}{x + 3}$

47. $y = \frac{8x - 3}{4x}$

48. $y = 15 - 6x$

49. $y = \frac{15 - 6x}{7x}$

50. $y = \frac{1}{(\sqrt{a})^t}$

51. When $a$ is positive, it has two real fourth roots, $\pm \sqrt[4]{a}$, and one real fifth root, $\sqrt[5]{a}$. When $a$ is negative, it has no real fourth roots and one real fifth root, $\sqrt[5]{a}$.

52. Chapter 6 Maintaining Mathematical Proficiency (p. 287)

1. $y^3$

2. $n$

3. $\frac{1}{x^3}$

4. $3x^3$

5. $\frac{8w^9}{x^6}$

6. $\frac{m^{10}}{x^4}$

7. $y = 2 - 4x$

8. $y = 3 + 3x$

9. $y = \frac{13}{7}x + \frac{9}{2}$

10. $y = \frac{5}{x + 3}$

11. $y = \frac{8x - 3}{4x}$

12. $y = 15 - 6x$

13. Sometimes; Order does not matter in Example 1 but does in Example 2.

6.1 Vocabulary and Core Concept Check (p. 293)

1. $\frac{1}{(\sqrt{a})^t}$

2. When $a$ is positive, it has two real fourth roots, $\pm \sqrt[4]{a}$, and one real fifth root, $\sqrt[5]{a}$. When $a$ is negative, it has no real fourth roots and one real fifth root, $\sqrt[5]{a}$.

6.1 Monitoring Progress and Modeling with Mathematics (pp. 293–294)

5. 2  7. 0  9. $-2$ 11. 2  13. 125

15. $-3$  17. $\frac{1}{4}$

19. The cube root of 27 was calculated incorrectly; $27^{1/3} = (27^{1/3})^3 = 3^3 = 27$

21. B: The denominator of the exponent is 3 and the numerator is 4.

23. A: The denominator of the exponent is 4 and the exponent is negative.

25. 8 27. 0.34 29. 2840.40 31. 50.57

33. $r = 3.72$ ft  35. $x = 5$  37. $x = -7.66$

39. $x = -2.17$  41. $x = \pm 2$  43. $x = \pm 3$

45. Potatoes: 3.7%; ham: 2.4%; eggs: 1.7%

47. 3, 4; $\sqrt[3]{8} = 2$ and $\sqrt[5]{256} = 4$  49. About 753 ft/sec

6.1 Maintaining Mathematical Proficiency (p. 294)

51. $5^5$  53. $\frac{1}{\sqrt{6}}$  55. 5000  57. 0.82

6.2 Vocabulary and Core Concept Check (p. 300)

1. No radicands have perfect nth powers as factors other than 1, no radicands contain fractions, and no radicals appear in the denominator of a fraction.

6.2 Monitoring Progress and Modeling with Mathematics (pp. 300–302)

3. $\sqrt[2]{9}$

5. $\sqrt[3]{64}$

7. $\sqrt[3]{5}$

9. $\sqrt[3]{3}$  11. 4

13. $\sqrt[2]{12}$

15. $\sqrt[2]{15}$

17. 3

19. $\sqrt[2]{6}$  21. $\sqrt[2]{3}$

23. $\sqrt[2]{\frac{10}{2}}$

25. $\sqrt[4]{6}$

27. $\sqrt[4]{\frac{4}{7}}$

29. $\sqrt[2]{\frac{1}{3}}$

31. $\sqrt[2]{15 + 5\sqrt{2}}$

33. $\sqrt[3]{9\sqrt{3} - 9\sqrt{7}}$

35. $\frac{3}{2} + \sqrt{30}$

37. $\sqrt[2]{12}$  39. $\sqrt[4]{12(\sqrt[3]{\frac{1}{4}})}$

41. $-9\sqrt[3]{2}$  43. $5\sqrt[2]{7}$

45. $6\sqrt[3]{3}$
47. The radicand should not change when the expression is factored: 
\[3\sqrt{12} + 5\sqrt{12} = (3 + 5)\sqrt{12} = 8\sqrt{12}\]

49. 3y^2  
51. \(\frac{m^2}{n}\)  
53. \([\frac{s}{h}]\)  

55. Absolute value was not used to ensure that all variables are positive: 
\[\sqrt{\frac{4g}{\sqrt{h^2}}r^6} = 2sr\]  

57. \(9a^3b^2c^2\sqrt{ac}\)  
59. \(\frac{2m\sqrt{5mn^3}}{n^2}\)  
61. \(\sqrt{\frac{u^5}{5w^6}}\)  

62. \(\frac{2\sqrt{3a}}{3w}\)

65. \(21\sqrt{5}\)

67. \(-2x^{7/2}\)

69. \(4w^2\sqrt{w}\)

71. \(P = 2x^3 + 4\sqrt{x^2}\)

73. about 0.14 mm

75. no; The second radical can be simplified to \(18\sqrt{11}\). The difference is \(-11\sqrt{11}\).

77. \(10 + 6\sqrt{5}\)

79. a. \(r = \sqrt{\frac{3V}{4\pi}}\)

b. \(S = 4\pi \left(\sqrt{\frac{3V}{4\pi}}\right)^2\)

\[S = 4\pi \left(\frac{3V^{2/3}}{(4\pi)^{2/3}}\right)\]

\[S = \left(\frac{4\pi^{1/3}}{3}\right)\left(3V^{2/3}\right)\]

\[S = \frac{4\pi^{1/3}V^{2/3}}{3}\]

c. The surface area of the larger balloon is \(2^{2/3} \approx 1.59\) times as large as the surface area of the smaller balloon.

81. When \(n\) is even and the simplified expression has an odd power of \(x\).

6.2 Maintaining Mathematical Proficiency (p. 302)

83. The focus is \((-\frac{1}{a}, 0)\). The directrix is \(x = \frac{1}{a}\). The axis of symmetry is \(y = 0\).

85. \(g(x) = -x^4 + 3x^2 + 2x\); The graph of \(g\) is a reflection in the \(y\)-axis of the graph of \(f\).

87. \(g(x) = (x - 2)^3 - 4\); The graph of \(g\) is a translation 2 units right of the graph of \(f\).

6.3 Vocabulary and Core Concept Check (p. 308)

1. radical

6.3 Monitoring Progress and Modeling with Mathematics (pp. 308–310)

3. B  
5. F  
7. E
19. The graph of $g$ is a translation 1 unit left and 8 units up of the graph of $f$.

![Graph of $g$ and $f$]

21. The graph of $g$ is a reflection in the $x$-axis followed by a translation 1 unit down of the graph of $f$.

![Graph of $g$ and $f$]

23. The graph of $g$ is a vertical shrink by a factor of $\frac{1}{3}$ followed by a reflection in the $y$-axis of the graph of $f$.

![Graph of $g$ and $f$]

25. The graph of $g$ is a vertical stretch by a factor of 2 followed by a translation 5 units left and 4 units down of the graph of $f$.

![Graph of $g$ and $f$]

27. The graph was translated 2 units left but it should be translated 2 units right.

![Graph of $g$ and $f$]

29. The domain is $x \leq -1$ and $x \geq 0$. The range is $y \geq 0$.

31. The domain is all real numbers. The range is $y \geq -\frac{\sqrt{2}}{2}$.

33. The domain is all real numbers. The range is $y \geq -\frac{\sqrt{14}}{4}$.

35. always 37. always 39. $g(x) = 2\sqrt{x} + 8$

41. $g(x) = \sqrt{9x + 4}$ 43. $g(x) = 2\sqrt{x + 1}$

45. $g(x) = 2\sqrt{x + 3}$ 47. $g(x) = 2\sqrt{(x + 5)^2 - 2}$

49. $y = 0.9\sqrt{x}$; 90 mi

51. $y = \pm \sqrt{x + 4}$

53. $y = \pm \sqrt{2 - x}$

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

57. The radius is 3 units. The $x$-intercepts are $\pm 3$. The $y$-intercepts are $\pm 3$.

59. $y = \pm \sqrt{1 - x^2}$

61. The radius is 6 units. The $x$-intercepts are $\pm 6$. The $y$-intercepts are $\pm 6$.

63. About 3 ft; Sample answer: Locate the $T$-value 2 on the graph and estimate the $\ell$ value.
65. [graph]

a. about 2468 hp  

b. about 0.04 mph/hp

67. a. the 165-lb skydiver

b. When \( A = 1 \), the diver is most likely vertical. When \( A = 7 \), the diver is most likely horizontal.

### 6.3 Maintaining Mathematical Proficiency (p. 310)

69. \( x = 1 \) and \( x = -\frac{7}{3} \)

71. \( x = 2 \) and \( x = 6 \)

73. \( -4 < x < -3 \)

75. \( x < 0.5 \) and \( x > 6 \)

### 6.4 Vocabulary and Core Concept Check (p. 318)

1. no; The radicand does not contain a variable.

### 6.4 Monitoring Progress and Modeling with Mathematics (pp. 318–320)

3. \( x = 7 \)

5. \( x = 24 \)

7. \( x = 6 \)

9. \( x = -\frac{1000}{3} \)

11. \( x = 1024 \)

13. about 21.7 yr

15. \( x = 12 \)

17. \( x = 14 \)

19. \( x = 0 \) and \( x = \frac{1}{2} \)

21. \( x = 3 \)

23. \( x = -1 \)

25. \( x = 4 \)

27. \( x = \pm 8 \)

29. no real solution

31. \( x = 3 \)

33. \( x = 5 \)

35. Only one side of the equation was raised to the third power; 

\[
\sqrt[3]{3x - 8} = 4 \\
(\sqrt[3]{3x - 8})^3 = 4^3 \\
3x - 8 = 64 \\
x = 24
\]

37. \( x \geq 64 \)

39. \( x > 27 \)

41. \( 0 \leq x \leq \frac{25}{4} \)

43. \( x > -220 \)

45. about 0.15 in.

47. (3, 0) and (4, 1);

49. (0, -2) and (2, 0);

51. (0, -1);

53. a. The greatest stopping distance is 450 feet on ice. On wet asphalt and snow, the stopping distance is 225 feet. The least stopping distance is 90 feet on dry asphalt.

b. about 272.2 ft; When \( s = 35 \) and \( f = 0.15 \), \( d = 272.2 \).

55. a. When solving the first equation, the solution is \( x = 8 \) with \( x = 2 \) as an extraneous solution. When solving the second equation, the solution is \( x = 2 \) with \( x = 8 \) as an extraneous solution.

57. The square root of a quantity cannot be negative.

59. Raising the price would decrease demand.

61. \( 36\pi \approx 113.1 \text{ ft}^2 \)

63. a. \( h = h_0 - \frac{k}{\pi^2} \) b. about 5.75 in.

### 6.4 Maintaining Mathematical Proficiency (p. 320)

65. \( g(x) = -\frac{1}{2}x^3 - 2x^2 \); The graph of \( g \) is a vertical shrink by a factor of \( \frac{1}{2} \) followed by a translation 3 units down of the graph of \( f \).

67. \( x^4 + x^2 - 2x = x + 1 \)

69. \( x^5 + 2x^4 + 5x^3 + 11x^2 + 5 \)

### 6.5 Vocabulary and Core Concept Check (p. 325)

1. You can add, subtract, multiply, or divide \( f \) and \( g \).

### 6.5 Monitoring Progress and Modeling with Mathematics (pp. 325–326)

3. \( (f + g)(x) = 14\sqrt[4]{x} \) and the domain is \( x \geq 0 \); \( (f - g)(x) = -24\sqrt[4]{x} \) and the domain is \( x \geq 0 \); \( (f + g)(16) = 28 \); \( (f - g)(16) = -48 \)

5. \( (f + g)(x) = -7x^3 + 5x^2 + x \) and the domain is all real numbers; \( (f - g)(x) = -7x^3 - 13x^2 + 11x \) and the domain is all real numbers; \( (f + g)(-1) = 11 \); \( (f - g)(-1) = -17 \)

7. \( (fg)(x) = 2x^{10/3} \) and the domain is all real numbers;

\[
\left(\frac{f}{g}\right)(x) = 2x^{8/3} \text{ and the domain is } x \neq 0 \; ; \; (fg)(-27) = 118,098; \\
\left(\frac{f}{g}\right)(-27) = 13,122
\]

9. \( (fg)(x) = 36x^{3/2} \) and the domain is \( x \geq 0 \); \( \left(\frac{f}{g}\right)(x) = \frac{4}{9}x^{1/2} \) and the domain is \( x > 0 \); \( (fg)(9) = 972; \left(\frac{f}{g}\right)(9) = \frac{4}{3} \)

11. \( (fg)(x) = -98x^{1/6} \) and the domain is \( x \geq 0 \); \( \left(\frac{f}{g}\right)(x) = -\frac{1}{2}x^{7/6} \) and the domain is \( x > 0 \); \( (fg)(64) = -200,704; \left(\frac{f}{g}\right)(64) = -64 \)

13. 2541.04; 2458.96; 102,598.56; 60.92

15. 7.76; -14.60; -38.24; -0.31

17. Because the functions have an even index, the domain is restricted; The domain of \( (fg)(x) \) is \( x \geq 0 \).
19. a. \((F + M)(t) = 0.0001t^3 - 0.016t^2 + 0.21t + 7.4\)
   b. the total number of employees from the ages of 16 to 19 in the United States
21. yes; When adding or multiplying functions, the order in which they appear does not matter.
23. \((f + g)(3) = -21; (f - g)(1) = -1; (fg)(2) = 0; \left(\frac{f}{g}\right)(0) = 2\)
25. \(r(x) = x^2 - \frac{1}{2}x^2 + \frac{1}{2}x^2\)
27. a. \(r(x) = \frac{20 - x}{6.4}; s(x) = \frac{\sqrt{x^2 + 144}}{0.9}\)
27. b. \(t(x) = \frac{20 - x}{6.4} + \frac{\sqrt{x^2 + 144}}{0.9}\)
27. c. \(x = 1.7;\) If Elvis runs along the shore until he is about 1.7 meters from point \(C\) then swims to point \(B\), the time taken to get there will be a minimum.

6.5 Maintaining Mathematical Proficiency (p. 326)
29. \(n = \frac{5z}{7 + 8z}\)
31. \(n = \frac{3}{7b - 4}\)
33. no; \(-1\) has two outputs.
35. no; \(2\) has two outputs.

6.6 Vocabulary and Core Concept Check (p. 333)
1. Inverse functions are functions that undo each other.
3. \(x, x\)

6.6 Monitoring Progress and Modeling with Mathematics (pp. 333–336)
5. \(x = y - \frac{5}{3}; \frac{8}{3}\)
7. \(x = 2y + 6; 0\)
9. \(x = \frac{3y - 1}{7}\)
11. \(x = 2 \pm \sqrt{y + 7}; 0, 4\)
13. \(f^{-1}(x) = \frac{1}{3}x^3;\)
15. \(f^{-1}(x) = \frac{x - 5}{-2};\)
17. \(f^{-1}(x) = -2x + 8;\)
19. \(f^{-1}(x) = 3x + \frac{1}{2};\)
21. \(f^{-1}(x) = \frac{x + 4}{-3};\) Sample answer: switching \(x\) and \(y\); You can graph the inverse to check your answer.
23. \(f^{-1}(x) = -\frac{\sqrt{x}}{2};\)
25. \(f^{-1}(x) = \sqrt[x]{x} + 3\)
27. \(f^{-1}(x) = \frac{\sqrt{x}}{2};\)
29. When switching $x$ and $y$, the negative should not be switched with the variables;
\[ y = -x + 3 \]
\[ x = -y + 3 \]
\[ -x + 3 = y \]
31. no; The function does not pass the horizontal line test.
33. no; The function does not pass the horizontal line test.
35. yes; $f^{-1}(x) = \sqrt[3]{x} + 1$
37. yes; $f^{-1}(x) = x^2 - 4$, where $x \geq 0$
39. yes; $f^{-1}(x) = \frac{x^3}{8} + 5$
41. no; $f^{-1}(x) = \pm \sqrt{x} - 2$
43. yes; $f^{-1}(x) = \frac{x^3}{27} - 1$
44. The functions are not inverses.
46. The functions are inverses.
47. \[ \ell = \left( \frac{v}{1.34} \right)^2; \text{about 31.3 ft} \]
51.
53. \[ w = 2 \ell - 6; \text{the weight of an object on a stretched spring of length } \ell \]
55.
59. When $x = 5$, $2x^2 + 3 = 53$.
61. a. $w = 2 \ell - 6$; the weight of an object on a stretched spring of length $\ell$
62. b. $5 \text{ lb}$
63. c. $0.5(2\ell - 6) + 3 = \ell; 2(0.5w + 3) - 6 = w$
65. B
67. A
69. a. false; All functions of the form $f(x) = x^n$, where $n$ is an even integer, fail the horizontal line test.
68. b. true; All functions of the form $f(x) = x^n$, where $n$ is an odd integer, pass the horizontal line test.
71. The inverse $y = \frac{1}{m}x - \frac{b}{m}$ has a slope of $\frac{1}{m}$ and a $y$-intercept of $\frac{-b}{m}$.

6.6 Maintaining Mathematical Proficiency (p. 336)
73. $-\frac{1}{3}$ 75. $4^2$
77. The function is increasing when $x > 1$ and decreasing when $x < 1$. The function is positive when $x < 0$ and negative when $0 < x < 2$.
79. The function is increasing when $-2.89 < x < 2.89$ and decreasing when $x < -2.89$ and $x > 2.89$. The function is positive when $x < -5$ and $0 < x < 5$ and negative when $-5 < x < 0$ and $x > 5$.

Chapter 6 Review (pp. 338–340)
1. 128 2. 243 3. $\frac{1}{9}$ 4. $x \approx 1.78$ 5. $x = 3$
6. $x = -10$ and $x = -6$
7. $\frac{6\sqrt[3]{5}}{6}$ 8. 4 9. $2 + \sqrt[3]{3}$
10. $\sqrt[3]{8}$ 11. $\sqrt[3]{7}$ 12. $5^{1/3} \cdot 2^{3/4}$ 13. $5z^3$
14. $\sqrt[6]{2z^6}$ 15. $-z^2\sqrt{10z}$
16. The graph of $g$ is a vertical stretch by a factor of 2 followed by a reflection in the $x$-axis of the graph of $f$.
17. The graph of $g$ is a reflection in the $y$-axis followed by a translation 6 units down of the graph of $f$.
18. $g(x) = \sqrt[3]{-x} - 7$
19. (8, 0); right.
20. The radius is 9. The $x$-intercepts are $\pm 9$. The $y$-intercepts are $\pm 9$.
21. $x = 62$
22. $x = 2$ and $x = 10$
23. $x = \pm 36$
24. $x > 9$
25. $8 \leq x < 152$
26. $x \geq 30$
27. about 4082 m
28. $(fg)(x) = 8(3 - x)^{1/6}$ and the domain is $x \leq 3$;
\[ \left( \frac{f}{g} \right)(x) = \frac{1}{2\sqrt[3]{3} - x} \text{ and the domain is } x < 3; (fg)(2) = 8; \]
\[ \left( \frac{f}{g} \right)(2) = \frac{1}{2} \]
29. $(f + g)(x) = 3x^2 + x + 5$ and the domain is all real numbers;
$(f - g)(x) = 3x^2 - x - 3$ and the domain is all real numbers;
$(f + g)(-5) = 75; (f - g)(-5) = 77$
7.1 Vocabulary and Core Concept Check (p. 352)

1. The initial amount is 2.4, the growth factor is 1.5, and the percent increase is 0.5 or 50%.

7.1 Monitoring Progress and Modeling with Mathematics (pp. 352–354)

3. a. \( \frac{1}{4} \)  b. 8
5. a. \( \frac{8}{9} \)  b. 216
7. a. \( \frac{46}{9} \)  b. 32
9. exponential growth

11. exponential decay

13. exponential growth

15. exponential growth

30. \( f^{-1}(x) = -2x + 20; \)

31. \( f^{-1}(x) = \sqrt{x} - 8; \)

32. \( f^{-1}(x) = \sqrt[3]{-x - 9}; \)

33. \( f^{-1}(x) = \frac{1}{2}(x - 5)^2, x \geq 5; \)

34. no  35. yes  36. \( p = \frac{d}{1.587}; \) about 63£

Chapter 7
Chapter 7 Maintaining Mathematical Proficiency (p. 345)

1. 48  2. -32  3. \( -\frac{25}{36} \)  4. \( \frac{27}{64} \)
5. domain: \(-5 \leq x \leq 5\), range: \(0 \leq y \leq 5\)
6. domain: \{-2, -1, 0, 1, 2\}, range: \{-5, -3, -1, 1, 3\}
7. domain: all real numbers, range: \( y \leq 0 \)
8. all values, odd values; no values, even values; The exponent of \(-4^n\) is evaluated first, then the result is multiplied by \(-1\), so the value will always remain negative. The product of an odd number of negative values is negative. After the exponent of \(-4^n\) is evaluated, the result is multiplied by \(-1\), so it will never be positive. The product of an even number of negative values is positive.
7.2 Vocabulary and Core Concept Check (p. 359)
1. Euler’s number is an irrational number called the natural base \( e \) and is approximately 2.718281828.

7.2 Monitoring Progress and Modeling with Mathematics (pp. 359–360)
3. \( e^8 \)
5. \( \frac{1}{2e} \)
7. \( 1 - 2e \)
9. \( 3e^3 \)
11. \( e^8 - 5x \)

13. The 4 was not squared; \((4e^3x)^2 = 4^2e^{6x} = 16e^{6x}\)

15. exponential growth

17. exponential decay

19. \( b = 3 \)
21. a. exponential decay  b. 25% decrease  c. in about 4.8 years
23. a. \( y = 233(1.06)^t \); about 261.8 million  b. 2009
25. Power of a Power Property; Evaluate power; Rewrite in form \( y = a(1 + r)^t \).
27. about 0.01%  29. \( y = a(1 + 0.26)^t \); 26% growth
31. \( y = a(1 - 0.06)^t \); 6% decay
33. \( y = a(1 - 0.04)^t \); 4% decay
35. \( y = a(1 + 255)^t \); 25,500% growth  37. \$5593.60

39. The percent decrease needs to be subtracted from 1 to produce the decay factor;
\[ y = \left( \frac{\text{Initial amount}}{\text{Decay factor}} \right)^t; \ y = 500(1 - 0.02)^t; \ y = 500(0.98)^t \]
41. \$3982.92  43. \$3906.18
45. \( a \) represents the number of referrals it received at the start of the model. \( b \) represents the growth factor of the number of referrals each year; 50%; \( 1.50 \) can be rewritten as \((1 + 0.50)\), showing the percent increase of 50%.
47. no; \( f(x) = 2^x \) eventually increases at a faster rate than \( g(x) = x^2 \) but not for all \( x \geq 0 \).
49. about 221.5; The curve contains the points (0, 6850) and (6, 8179.26) and \( \frac{8179.26 - 6850}{6 - 0} = 221.5 \).
51. a. The decay factor is 0.9978. The percent decrease is 0.22%.

b. 

![Eggs Produced by Leghorn](image)

c. about 134 eggs per year
d. Replace \( \frac{w}{25} \) with \( y \), where \( y \) represents the age of the chicken in years.

7.1 Maintaining Mathematical Proficiency (p. 354)
53. \( x^{11} \)  55. \( 24x^2 \)  57. \( 2x \)  59. \( 3 + 5x \)
31. \( y = 3\sqrt{-x + 2} \)

33. \( y = -\sqrt{x + 1} \)

35. the education fund; the education fund

37. Sample answer: \( a = 6, b = 2, r = -0.2, q = -0.7 \)

39. no; \( e \) is an irrational number. Irrational numbers cannot be expressed as a ratio of two integers.

41. account 1: With account 1, the balance would be

\[
A = 2500 \left(1 + \frac{0.06}{4}\right)^{4 \times 10} = \$4535.05.
\]

With account 2, the balance would be

\[
A = 2500e^{0.04 \times 10} = \$3729.56.
\]

43. a. \( N(t) = 30e^{0.166t} \)

b. 900

c. At 3:45 P.M., it has been 2 hours and 45 minutes, or 2.75 hours, since 1:00 P.M. Using the trace feature of the calculator, type 2.75 to find the point \((2.75, 47.356183)\). At 3:45 P.M., there are about 47 cells.

7.3 Vocabulary and Core Concept Check (p. 366)

1. common 3. They are inverse functions.

7.3 Monitoring Progress and Modeling with Mathematics (pp. 366–368)

5. \( 3^2 = 9 \)

7. \( 6^0 = 1 \)

9. \( \left( \frac{1}{2} \right)^{-4} = 16 \)

11. \( \log_6 36 = 2 \)

13. \( \log_{16} \frac{1}{16} = -1 \)

15. \( \log_{125} 25 = \frac{2}{3} \)

17. 4 19. 1 21. -4 23. -1

25. \( \log_7 8, \log_5 23, \log_6 38, \log_{10} 10 \)

27. 0.778

29. -1.099

31. -2.079

33. 4603 m

35. \( \log 7 \left( \frac{1}{2} \right) \)

37. a. about 283 mi/h

b. \( d = 10^6 - 65^{0.03} \); The inverse gives the distance a tornado will travel given the wind speed, \( s \).

57. The domain of \( f \) is \( x > 0 \) and the range is all real numbers.
d. The number of species of fish increases; *Sample answer:* This makes sense because in a smaller pool or lake, one species could dominate another more easily and feed on the weaker species until it became extinct.

73. a. $\frac{2}{3}$  b. $\frac{5}{3}$  c. $\frac{4}{3}$  d. $\frac{7}{2}$

7.3 Maintaining Mathematical Proficiency  (p. 368)
75. $g(x) = \sqrt{x - 1} - 2$
77. $g(x) = \sqrt{x + 2}$
79. quadratic; The graph is a translation 2 units left and 1 unit down of the parent quadratic function.

7.4 Vocabulary and Core Concept Check  (p. 374)
1. Positive values of $a$ vertically stretch ($a > 1$) or shrink ($a < 1$) the graph of $f$. $h$ translates the graph of $f$ left ($h < 0$) or right ($h > 0$). $k$ translates the graph of $f$ up ($k > 0$) or down ($k < 0$). When $a$ is negative, the graph of $f$ is reflected in the $x$-axis.

7.4 Monitoring Progress and Modeling with Mathematics  (pp. 374–376)
3. C; The graph of $f$ is a translation 2 units left and 2 units down of the graph of the parent function $y = 2^x$.
5. A; The graph of $h$ is a translation 2 units right and 2 units down of the graph of the parent function $y = 2^x$.
7. The graph of $g$ is a translation 5 units up of the graph of $f$.

9. The graph of $g$ is a translation 1 unit down of the graph of $f$.

11. The graph of $g$ is a translation 7 units right of the graph of $f$. 

59. 

The domain of $f$ is $x > 0$ and the range is all real numbers.

61. 

The domain of $f$ is $x > 0$ and the range is all real numbers.

63. 

domain: $x > -2$, range: all real numbers, asymptote: $x = -2$

65. 

domain: $x < 0$, range: all real numbers, asymptote: $x = 0$

67. no; Any logarithmic function of the form $g(x) = \log_b x$ will pass through $(1, 0)$, but if the function has been translated or reflected in the $x$-axis, it may not pass through $(1, 0)$.

69. a. 

b. about 281 lb

c. $(3.4, 0)$; no; The $x$-intercept shows that an alligator with a weight of 3.4 pounds has no length. If an object has weight, it must have length.

71. a. 

b. 15 species  c. about 3918 m$^2$
13. The graph of $g$ is a reflection in the $x$-axis of the graph of $f$.

15. The graph of $g$ is a translation 3 units right and 12 units up of the graph of $f$.

17. The graph of $g$ is a vertical stretch by a factor of 2 of the graph of $f$.

19. The graph of $g$ is a vertical stretch by a factor of 3 followed by a translation 3 units right of the graph of $f$.

21. The graph of $g$ is a horizontal shrink by a factor of $\frac{1}{3}$ followed by a vertical stretch by a factor of 3 of the graph of $f$.

23. The graph of $g$ is a vertical stretch by a factor of 6 followed by a translation 5 units left and 2 units down of the graph of $f$.

25. The graph of the parent function $f(x) = 2^x$ was translated 3 units left instead of up.

27. The graph of $g$ is a vertical stretch by a factor of 3 followed by a translation 5 units up of the graph of $f$.

29. The graph of $g$ is a reflection in the $x$-axis followed by a translation 7 units right of the graph of $f$.

31. $A; The graph of $f$ has been translated 2 units right.

33. $C; The graph of $f$ has been stretched vertically by a factor of 2.

35. $g(x) = -2^x + 2$

37. $g(x) = e^{2x} + 5$

39. $g(x) = 6 \log x - 5$

41. $g(x) = \log(-x - 3) + 2$

43. Multiply the output by $-1$; Substitute $\ln x$ for $f(x)$.

45. The graph of $g$ is a translation 4 units up of the graph of $f$; $y = 4$

47. The graph of $g$ is a translation 6 units left of the graph of $f$; $x = -6$
49. The graph of $f$ is a vertical shrink by a factor of 0.118 followed by a translation 0.159 units up of the graph of $f$; For fine sand, the slope of the beach is about 0.05. For medium sand, the slope of the beach is about 0.09. For coarse sand, the slope of the beach is about 0.12. For very coarse sand, the slope of the beach is about 0.16.

51. Yes; Sample answer: When the graph is reflected in the $y$-axis, the graphs will never intersect because there are no values of $x$ where $\log x = \log(-x)$.

53. a. never; The asymptote of $f(x) = \log x$ is a vertical line and would not change by shifting the graph vertically.

b. always; The asymptote of $f(x) = e^x$ is a horizontal line and would be changed by shifting the graph vertically.

c. always; The domain of $f(x) = \log x$ is $x > 0$ and would not be changed by a horizontal shrink.

d. sometimes; The graph of the parent exponential function does not intersect the $x$-axis, but when it is shifted down, the graph would intersect the $x$-axis.

55. The graph of $f$ is a translation 2 units right of the graph of $f$; The graph of $h$ is a reflection in the $y$-axis followed by a translation 2 units left of the graph of $g$; $x$ has been replaced with $x - 2$. $x$ has been replaced with $-(x + 2)$.

7.5 Maintaining Mathematical Proficiency (p. 376)

57. $(f \circ g)(x) = x^6$; $(g \circ f)(3) = 729$

59. $(f + g)(x) = 14x^3$; $(f + g)(2) = 112$

7.5 Vocabulary and Core Concept Check (p. 383)

1. Product

7.5 Monitoring Progress and Modeling with Mathematics (pp. 383–384)

3. $0.565 \quad 5. \quad 1.424 \quad 7. \quad -0.712$

9. B; Quotient Property

11. A; Power Property

13. $\log_3 4 + \log_3 x \quad 15. \quad 1 + 5 \log x$

17. $\ln x - \ln 3 - \ln y \quad 19. \quad \log_5 5 + \frac{1}{2} \log_5 x$

21. The two expressions should be added, not multiplied; $\log_3 5x = \log_3 5 + \log_3 x$

23. $\log_4 7 \quad 25. \quad \ln xy^4 \quad 27. \quad \log_3 4\sqrt{x} \quad 29. \quad \ln 32x^2y^4$

31. B; $\log_5 \frac{x^4}{3x} = \log_5 x^4 - \log_5 3x$ Quotient Property

= $4 \log_5 x - (\log_5 3 + \log_5 x)$ Power and Product Properties

= $4 \log_5 x - \log_5 3 - \log_5 x$ Distributive Property

33. 1.404 \quad 35. 1.232 \quad 37. 1.581 \quad 39. $-0.860$

41. Yes; Using the change-of-base formula, the equation can be graphed as $y = \frac{\log x}{\log 3}$.

43. 60 decibels

45. a. $2 \ln 2 \approx 1.39$ knots

b. $s(h) = 2 \ln 100h$

$c. s(h) = \ln(100h)^2$

$d. s(h) = (\ln h)^2$

$e. s(h) = 2 \log(100h)$

$s(h) = 2(\log 100 + \log h)$

$s(h) = 2 + \log h$

$s(h) = \frac{2}{\log e}$

47. Rewrite each logarithm to obtain $a = b^c$, $c = b^x$, and $a = c^y$.

So, $\log_b a = \log_b b^c = \frac{c \log_b c}{\log_b c} = c = \log_b a$

7.5 Maintaining Mathematical Proficiency (p. 384)

49. $x < -2$ or $x > 2 \quad 51. \quad -7 < x < -6$

53. $x \approx -0.76$ and $x \approx 2.36 \quad 55. \quad x \approx -1.79$ and $x \approx 1.12$

7.6 Vocabulary and Core Concept Check (p. 390)

1. Exponential

3. The domain of a logarithmic function is positive numbers only, so any value of the variable that results in taking the log of a non-positive number will be an extraneous solution.

7.6 Monitoring Progress and Modeling with Mathematics (pp. 390–392)

5. $x = -1 \quad 7. \quad x = 7 \quad 9. \quad x \approx 1.771 \quad 11. \quad x = -\frac{5}{3}$

13. $x \approx 0.255 \quad 15. \quad x \approx 0.173 \quad 17. \quad$ About 17.6 years old

19. About 50 min

21. $x = 6 \quad 23. \quad x = 3 \quad 25. \quad x = 6$

27. $x = 10 \quad 29. \quad x = 1$

31. $x = \frac{1 + \sqrt{41}}{2} \approx 3.7$ and $x = \frac{1 - \sqrt{41}}{2} \approx -2.7$

33. $x = 4 \quad 35. \quad x \approx 6.04 \quad 37. \quad x = \pm 1 \quad 39. \quad x \approx 10.24$

41. 3 should be the base on both sides of the equation; $\log_3(x - 1) = 4$

$3\log_3(x - 1) = 3^4$

$5x = 82$

$x = 16.4$

43. a. $39.52$ years \quad b. $38.66$ years \quad c. $38.38$ years

45. a. $x \approx 3.57 \quad$ b. $x = 0.8 \quad$ 47. $x > 1.815$

49. $x \geq 20.086 \quad 51. \quad x < 1.723 \quad 53. \quad x \geq 0.2$

55. $0 < x < 25$; Sample answer: algebraically; Rewriting the equation in exponential form is the easiest method because it isolates the variable.

57. $r > 0.0718$ or $r > 7.18%$ \quad 59. $x \approx 1.78$

61. No solution

63. a. $a = -\frac{1}{0.09} \ln \left( \frac{45 - 6}{25.7} \right)$

b. $36$ cm footprint: $11.7$ years old; $32$ cm footprint: $7.6$ years old; $28$ cm footprint: $4.6$ years old; $24$ cm footprint: $2.2$ years old

65. Sample answer: $2^x = 16$; $\log_3(-x) = 1$

67. $x \approx 0.89$

69. $x \approx 10.61 \quad 71. \quad x = 2$ and $x = 3$
73. To solve exponential equations with different bases, take
a logarithm of each side. Then use the Power Property to
move the exponent to the front of the logarithm, and solve
for x. To solve logarithmic equations of different bases, find
a common multiple of the bases, and exponentiate each side
with this common multiple as the base. Rewrite the base as a
power that will cancel out the given logarithm and solve the
resulting equation.

7.6 Maintaining Mathematical Proficiency  (p. 392)
75. y + 2 = 4(x - 1)  77. y + 8 = \frac{1}{3}(x - 3)
79. 3; y = 2x^3 - x + 1
81. 4; y = -3x^3 + 2x^3 - x^2 + 5x - 6
7.7 Vocabulary and Core Concept Check   (p. 398)
1. common ratio; natural number
7.7 Monitoring Progress and Modeling with
Mathematics  (pp. 398-400)
3. exponential; The data have a common ratio of 4.
5. quadratic; The second differences are constant.
7. y = 0.75(4)^x  9. y = \frac{1}{2}(2)^x  11. y = \frac{3}{5}(3)^x
13. y = 5(0.5)^x  15. y = 0.25(2)^x
17. Data are linear when the first differences are constant; The
outputs have a common ratio of 3, so the data represents an
exponential function.
19. Sample answer: y = 7.20(1.39)^x; no
21. yes; Sample answer: y = 8.88(1.21)^x
23. yes; Sample answer: y = 71.47(0.98)^x
25. f(0) = 3, f(n) = 7 \cdot f(n - 1)
27. f(0) = 12, f(n) = 8 \cdot f(n - 1)
29. f(0) = 0.5, f(n) = 3 \cdot f(n - 1)
31. f(0) = 4, f(n) = \frac{1}{5} \cdot f(n - 1)
33. The inputs are equally spaced and the common ratio is 2;
   f(0) = 0.75, f(n) = 2 \cdot f(n - 1)
35. The inputs are equally spaced and the common ratio is \frac{1}{2};
   f(0) = 96, f(n) = \frac{1}{2} \cdot f(n - 1)
37. \begin{array}{c|ccccc}
   n & 0 & 1 & 2 & 3 & 4 & 5 \\
   \hline
   f(n) & 4 & 12 & 36 & 108 & 324 & 972 \\
\end{array}
39. y = 6.70(1.41)^x; about 208 scooters
41. t = 12.59 - 2.55 \ln d; 2.6 h
43. a. Sample answer: y = 0.50(1.47)^x; f(1) = 0.751,
   f(n) = 1.47 \cdot f(n - 1)
   b. about 47%; The base is 1.47 which means that the
   function shows 47% growth.
45. no; When d is the independent variable and t is the dependent
variable, the data can be modeled with a logarithmic
function. When the variables are switched, the data can be
modeled with an exponential function.

47. a. 5.9 weeks
b. The asymptote is the line y = 256 and represents
   the maximum height of the sunflower.

7.7 Maintaining Mathematical Proficiency  (p. 400)
49. no; When one variable is increased by a factor, the other
   variable does not increase by the same factor.
51. yes; When one variable is increased by a factor, the other
   variable increases by the same factor.
53. The focus is \( (0, \frac{1}{16}) \), the directrix is \( y = -\frac{1}{16} \), and the axis of
   symmetry is \( x = 0 \).
55. The focus is (0.1, 0), the directrix is \( x = -0.1 \), and the axis
   of symmetry is \( y = 0 \).

Chapter 7 Review (pp. 402-404)
1. exponential decay; 66.67% decrease
2. exponential growth; 400% increase

3. exponential decay; 80% decrease

4. $1725.39
5. $e^{15} 
6. $\frac{2}{e^3}$
7. $9e^{-10x}$
8. exponential growth

9. exponential decay

10. exponential decay

11. $\log_2 8 = x; x = 3$
12. $x^2 = 36; x = 6$
13. $5^3 = x; x = 125$
14. $f^{-1}(x) = \log_8 x$
15. $f^{-1}(x) = e^x + 4$
16. $f^{-1}(x) = 10^x - 9$
17. The domain of $f$ is $x > 0$ and the range is all real numbers.
18. The graph of $g$ is a horizontal shrink by a factor of $\frac{1}{3}$ followed by a translation 8 units down of the graph of $f$.
19. The graph of $g$ is a vertical shrink by a factor of $\frac{1}{2}$ followed by a translation 5 units left of the graph of $f$.
20. $g(x) = 3e^x + 6 + 3$
21. $g(x) = \log(-x) - 2$
22. $\log_8 3 + \log_8 x + \log_8 y$
23. $1 + 3 \log x + \log y$
24. $\ln 3 + \ln y - 5 \ln x$
25. $\log_2 384$
26. $\log_2 \frac{12}{x^2}$
27. $\ln 4x^2$
28. about 3.32
29. about 1.13
30. about 1.19
31. $x = 1.29$
32. $x = 7$
33. $x \approx 3.59$
34. $x > 1.39$
35. $0 < x \leq 8103.08$
36. $x \geq 1.19$
37. $y = 64(1.3)^x$
38. Sample answer: $y = 3.60(1.43)^x$
39. $s = 3.95 + 27.48 \ln t$; 53 pairs

Chapter 8
Chapter 8 Maintaining Mathematical Proficiency (p. 409)
1. $\frac{19}{15}$ or $1 \frac{4}{15}$
2. $-\frac{17}{42}$
3. $\frac{1}{3}$
4. $\frac{11}{12}$
5. $-\frac{3}{7}$
6. $-\frac{1}{20}$
7. $9 \frac{9}{20}$
8. $-\frac{7}{20}$
9. $8 \frac{8}{11}$
10. 0; Division by zero is not possible.

8.1 Vocabulary and Core Concept Check (p. 415)
1. The ratio of the variables is constant in a direct variation equation, and the product of the variables is constant in an inverse variation equation.
8.1 Monitoring Progress and Modeling with Mathematics (pp. 415–416)
3. inverse variation  5. direct variation  7. neither
9. direct variation  11. direct variation
13. inverse variation  15. \( y = \frac{-20}{x}; y = \frac{-20}{3} \)
17. \( y = \frac{-24}{x}; y = -8 \)  19. \( y = \frac{21}{x}; y = 7 \)
21. \( y = \frac{2}{x}; y = \frac{2}{3} \)
23. The equation for direct variation was used; Because \( 5 = \frac{a}{8} \), \( a = 40 \). So, \( y = \frac{40}{x} \).
25. a. | Size | 2 | 2.5 | 3 | 5 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of songs</td>
<td>5000</td>
<td>4000</td>
<td>3333</td>
<td>2000</td>
</tr>
</tbody>
</table>

b. The number of songs decreases.
27. \( \frac{A}{c} = \frac{26,000}{c} \); about 321 chips per wafer
29. yes; The product of the number of hats and the price per hat is $50, which is constant.
31. Sample answer: As the speed of your car increases, the number of minutes per mile decreases.
33. cat: 4 ft, dog: 2 ft; The inverse equations are \( d = \frac{a}{7} \) and \( d - 6 = \frac{a}{14} \). Because the constant is the same, solve the equation \( 7d = 14(6 - d) \) for \( d \).

8.1 Maintaining Mathematical Proficiency (p. 416)
35. \( x^2 - 6 \)
37. domain: all real numbers, range: \( y > 0 \)
39. domain: \( x > -9 \), range: all real numbers

8.2 Monitoring Progress and Modeling with Mathematics (pp. 422–424)
3. The graph of \( g \) lies farther from the axes. Both graphs lie in the first and third quadrants and have the same asymptotes, domain, and range.

5. The graph of \( g \) lies farther from the axes and is reflected over the \( x \)-axis. Both graphs have the same asymptotes, domain, and range.

7. The graph of \( g \) lies closer to the axes and is reflected over the \( x \)-axis. Both graphs have the same asymptotes, domain, and range.

9. The graph of \( g \) lies closer to the axes. Both graphs lie in the first and third quadrants and have the same asymptotes, domain, and range.

8.2 Vocabulary and Core Concept Check (p. 422)
1. range; domain
11. domain: $\{x \mid x \neq 0\}$; range: $\{y \mid y \neq 3\}$

13. domain: $\{x \mid x \neq 1\}$; range: $\{y \mid y \neq 0\}$

15. domain: $\{x \mid x \neq -2\}$; range: $\{y \mid y \neq 0\}$

17. domain: $\{x \mid x \neq 4\}$; range: $\{y \mid y \neq -1\}$

19. The graph should lie in the second and fourth quadrants instead of the first and third quadrants.

21. A; The asymptotes are $x = 3$ and $y = 1$.
23. B; The asymptotes are $x = 3$ and $y = -1$.
25. domain: $(-\infty, 3)$ and $(3, \infty)$; range: $(-\infty, 1)$ and $(1, \infty)$

27. domain: $(-\infty, 2)$ and $(2, \infty)$; range: $(-\infty, \frac{1}{4})$ and $(\frac{1}{4}, \infty)$

29. domain: $(-\infty, -\frac{5}{4})$ and $(-\frac{5}{4}, \infty)$; range: $(-\infty, -\frac{5}{4})$ and $(-\frac{5}{4}, \infty)$
31. domain: \((-\infty, -\frac{3}{2})\) and \((-\frac{3}{2}, \infty)\); range: \((-\infty, \frac{5}{2})\) and \((\frac{5}{2}, \infty))

33. \(g(x) = \frac{1}{x+1} + 5\); translation 1 unit left and 5 units up

35. \(g(x) = \frac{6}{x-5} + 2\); translation 5 units right and 2 units up

37. \(g(x) = \frac{24}{x-6} + 1\); translation 6 units right and 1 unit up

39. \(g(x) = \frac{-111}{x + 13} + 7\); translation 13 units left and 7 units up

41. a. 50 students
   b. The average cost per student approaches $20.

43. B

45. a. about 23°C  b. 0.005 sec/°C

47. even

49. odd

51. yes; A rational function can have more than one vertical asymptote when the denominator is zero for more than one value of \(x\), such as \(y = \frac{3}{(x + 1)(x - 1)}\).

53. \(y = x, y = -x\); The function and its inverse are the same.

55. (4, 3); The point (2, 1) is one unit left and one unit down from (3, 2), so a point on the other branch is one unit right and one unit up from (3, 2).

57. The competitor is a better choice for less than 8 months of service; The cost of Internet service is modeled by \(C = \frac{50 + 43x}{x}\). So, the average monthly charge gets closer to $43 as the number of months of service increases.

8.2 Maintaining Mathematical Proficiency (p. 424)

59. \(4(x - 5)(x + 4)\)

61. \(2(x - 3)(x + 2)\)

63. \(3^6\)

65. \(6^{2/3}\)

8.3 Vocabulary and Core Concept Check (p. 432)

1. To multiply rational expressions, multiply numerators, then multiply denominators, and write the new fraction in simplified form. To divide one rational expression by another, multiply the first rational expression by the reciprocal of the second rational expression.

8.3 Monitoring Progress and Modeling with Mathematics (pp. 432–434)

3. \(\frac{2x}{3x - 4}, x \neq 0\)

5. \(\frac{x + 3}{x - 1}, x \neq 6\)

7. \(\frac{x + 9}{x^2 - 2x + 4}, x \neq -2\)

9. \(\frac{2(4x^2 + 5)}{x - 3}, x \neq \pm \frac{5}{\sqrt{4}}\)

11. \(\frac{y^3}{2y^2}, y \neq 0\)

13. \(x + 6, x \neq 0, x \neq 3\)

15. \((x - 3)(x + 3), x \neq 0, x \neq 2\)
17. \( \frac{2x(x + 4)}{(x + 2)(x - 3)} \), \( x \neq 1 \)  
19. \( \frac{(x + 9)(x - 4)^2}{(x + 7)} \), \( x \neq 7 \)  
21. The polynomials need to be factored first, and then the common factors can divide out; \( \frac{x + 12}{x + 4} \)  
23. B  
25. The expressions have the same simplified form, but the domain of \( f \) is \( \{ x \mid x \neq \frac{3}{2} \} \) and the domain of \( g \) is all real numbers.  
27. \( \frac{256x^7}{y^{14}} \), \( x \neq 0 \)  
29. \( \frac{x - 1}{2x + 4} \), \( x \neq -2, x \neq 1 \)  
31. \( \frac{(x + 2)}{(x + 4)(x - 3)} \)  
35. a. \( \frac{2(r + x)}{rx} \)  
   b. soup: 0.784, coffee: 0.382, paint: 0.341  
   c. paint, coffee, soup; The paint can has the smallest efficiency ratio.  
37. \( M = \frac{171r + 1361}{(1 + 0.018r)(2960r + 278,649)} ; 58443 \)  
39. a. The population increases by 2960 people each year.  
   b. The population was 278,649 people in 2010.  
41.  
<table>
<thead>
<tr>
<th>( x )</th>
<th>( y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.5</td>
<td>-0.1333</td>
</tr>
<tr>
<td>-3.8</td>
<td>-0.1282</td>
</tr>
<tr>
<td>-3.9</td>
<td>-0.1266</td>
</tr>
<tr>
<td>-4.1</td>
<td>-0.1235</td>
</tr>
<tr>
<td>-4.2</td>
<td>-0.1220</td>
</tr>
</tbody>
</table>

The graph does not have a value for \( y \) when \( x = -4 \).  
43. \( \frac{4}{7x} \)  
45. \( 9(x + 3) \), \( x \neq -\frac{3}{2}, x \neq \frac{5}{2}, x \neq 7 \)  
47. a. \( \frac{2(h + r)}{rh} \)  
   b. Galapagos: 0.371, King: 0.203  
   c. King; A King penguin has a smaller efficiency ratio, so it can live in a colder climate.  
49. \( f(x) = \frac{x(x - 1)}{x + 2}, g(x) = \frac{x(x + 2)}{x - 1} \)  

8.3 Maintaining Mathematical Proficiency (p. 434)  
51. \( x = -\frac{25}{5} \)  
53. \( x = \frac{32}{15} \)  
55. \( 7 \cdot 13 \)  
57. prime  

8.4 Vocabulary and Core Concept Check (p. 440)  
1. complex fraction  

8.4 Monitoring Progress and Modeling with Mathematics (pp. 440–442)  
3. \( \frac{5}{x} \)  
5. \( \frac{9 - 2x}{x + 1} \)  
7. \( 5, x \neq -3 \)  
9. \( 3x(x - 2) \)  
11. \( 2x(x - 5) \)  
13. \( (x + 5)(x - 3) \)  
15. \( (x - 5)(x + 8)(x - 8) \)  
17. The LCM of \( 5x \) and \( x^2 \) is \( 5x^2 \), so multiply the first term by \( \frac{x}{x} \) and the second term by \( \frac{5}{5} \) before adding the numerators; \( \frac{2(x + 10)}{5x^2} \)  
19. \( \frac{37}{30x} \)  
21. \( \frac{2(x + 7)}{(x + 4)(x + 6)} \)  
23. \( \frac{3(x + 12)}{(x + 8)(x - 3)} \)  
25. \( \frac{8x^3 - 9x^2 - 28x + 8}{x(x - 4)(3x - 1)} \)  
27. sometimes; When the denominators have no common factors, the product of the denominators is the LCD. When the denominators have common factors, use the LCM to find the LCD.  
29. A  
31. \( g(x) = \frac{-2}{x - 1} + 5 \)  

The graph of \( g \) is a translation 1 unit right and 5 units up of the graph of \( f(x) = \frac{-2}{x} \).  
33. \( g(x) = \frac{60}{x - 5} + 12 \)  

The graph of \( g \) is a translation 5 units right and 12 units up of the graph of \( f(x) = \frac{60}{x} \).  
35. \( g(x) = \frac{3}{x} + 2 \)  

The graph of \( g \) is a translation 2 units up of the graph of \( f(x) = \frac{3}{x} \).
37. \( g(x) = \frac{20}{x - 3} + 3 \)

The graph of \( g \) is a translation 3 units right and 3 units up of the graph of \( f(x) = \frac{20}{x} \).

39. \( \frac{x(x - 18)}{6(5x + 2)}, x \neq 0 \)
41. \( -\frac{3}{4x}, x \neq 0 \)
43. \( \frac{x - 4}{12(x - 1)^2}, x \neq 1, x \neq 4 \)
45. \( T = \frac{2ad}{(a + j)(a - j)} \); about 10.2 h

47. \( y = \frac{20(7x + 60)}{x(x + 30)} \)

49. no; The LCM of 2 and 4 is 4, which is greater than one number and equal to the other number.

51. \( a. \quad M = \frac{\Pi}{1 - \left(1 + \frac{1}{i}\right)^{12r}} = \frac{\Pi}{1 - \left(1 + \frac{1}{i}\right)^{12r}} = \frac{\Pi(1 + i)^{12r}}{(1 + i)^{12r} - 1} \)

b. $364.02

53. \( g(x) = \frac{2.3058}{x + 12.2} + 0.003; \) translation 12.2 units left and 0.003 unit up of the graph of \( f \)

55. \( a. \quad R_1 = \frac{1}{40}, R_2 = \frac{1}{x}, R_1 = \frac{1}{x + 10} \)

b. \( R = \frac{x^2 + 90x + 400}{40(x + 10)} \)

c. about 0.0758 car/min; about 4.5 cars/h; Multiply the number of cars washed per minute by the rate 60 min/h to obtain an answer in cars per hour.

57. \( 1 + \frac{1}{2 + 1}, 1 + \frac{1}{2 + \frac{1}{2 + \frac{1}{2}}} = \frac{1}{2 + \frac{1}{2 + \frac{1}{2}}} = \frac{1}{2 + \frac{1}{2 + \frac{1}{2}}} \)

1.4, 1.4167, 1.4138, 1.4143, 1.4142; \( \sqrt{2} \)

8.5 Monitoring Progress and Modeling with Mathematics (pp. 448–450)

3. \( x = 4 \)  5. \( x = 5 \)  7. \( x = -5, x = 7 \)

9. \( x = -1, x = 0 \)

11. 26 serves

13. 20.5 oz

15. \( x(x + 3) \)

17. \( 2(x + 1)(x + 4) \)

19. \( x = 2 \)

21. \( x = \frac{7}{2} \)  23. \( x = -\frac{3}{2}, x = 2 \)

25. no solution

27. \( x = -2, x = 3 \)  29. \( x = -\frac{3 + \sqrt{129}}{4} \)

31. Each side of the equation should be multiplied by the LCD:

\( 3x^2 \cdot \frac{5}{3x} + 3x^2 \cdot \frac{2}{x^2} = 3x^2 \cdot 1 \)

33. a.

<table>
<thead>
<tr>
<th>Work rate</th>
<th>Time</th>
<th>Work done</th>
</tr>
</thead>
<tbody>
<tr>
<td>You</td>
<td>1 room</td>
<td>8 hours</td>
</tr>
<tr>
<td>Friend</td>
<td>1 room</td>
<td>t hours</td>
</tr>
</tbody>
</table>

b. The sum is the amount of time it would take for you and your friend to paint the room together; \( \frac{5}{8} + \frac{5}{t} = 1 \).

\[ t = 13.3 \text{ h} = 13 \text{ h} 20 \text{ min} \]

35. Sample answer: \( x + \frac{1}{x + 2} = \frac{3}{x + 4} \). Cross multiplication can be used when each side of the equation is a single rational expression; Sample answer: \( x + \frac{1}{x + 2} + \frac{3}{x + 4} = \frac{1}{x + 3} \).

Multiplying by the LCD can be used when there is more than one rational expression on one side of the equation.

37. yes; \( f^{-1}(x) = \frac{2}{x} + 4 \)  39. yes; \( f^{-1}(x) = -\frac{3}{x + 2} \)

41. yes; \( f^{-1}(x) = -\frac{2}{x} + \frac{11}{2} \)  43. no; \( f^{-1}(x) = \pm \frac{1}{\sqrt{x - 4}} \)

45. a. about 21 mi/gal  b. about 21 mi/gal

47. \( x = 0.8165 \)  49. \( x = 1.3247 \)  51. \( \frac{1 + \sqrt{5}}{2} \)

53. \( f^{-1}(x) = \frac{4x + 1}{x - 3} \)

55. \( y^{-1} = \frac{b - xd}{xc - a} \)

57. a. always true; When \( x = a \), the denominators of the fractions are both zero.

b. sometimes true; The equation will have exactly one solution except when \( x = a \).

c. always true; \( x = a \) is an extraneous solution, so the equation has no solution.

8.5 Maintaining Mathematical Proficiency (p. 450)

59. discrete; The number of quarters in your pocket is an integer.
19. \(5x^2 - 11x - 9\) \(=\) \((x + 8)(x - 3)\)

20. \(\frac{-2(2x^2 + 3x + 3)}{(x - 3)(x + 3)(x + 1)}\)

21. \(g(x) = \frac{16}{x - 3} + 5;\) translation 3 units right and 5 units up of the graph of \(f\)

22. \(g(x) = \frac{-26}{x + 7} + 4;\) translation 7 units left and 4 units up of the graph of \(f\)

23. \(g(x) = \frac{-1}{x - 1} + 9;\) translation 1 unit right and 9 units up of the graph of \(f\)

24. \(\frac{pq}{p + q};\) \(p \neq 0, q \neq 0\)

25. \(x = 5\)

26. no solution

27. no solution

28. yes; \(f^{-1}(x) = \frac{3}{x} - 6\)

29. yes; \(f^{-1}(x) = \frac{10}{x} + 7\)

30. yes; \(f^{-1}(x) = \frac{1}{x - 8}\)

31. a. 4 games  b. 4 games