5.1 Exercises

In Exercises 1-6, sketch the image of your calculator screen on your homework paper. Label and scale each axis with xmin, xmax, ymin, and ymax. Label each graph with its equation. Remember to use a ruler to draw all lines, including axes.

1. Use your graphing calculator to sketch the graphs of \( f(x) = x^2 \), \( g(x) = 2x^2 \), and \( h(x) = 4x^2 \) on one screen. Write a short sentence explaining what you learned in this exercise.

2. Use your graphing calculator to sketch the graphs of \( f(x) = -x^2 \), \( g(x) = -2x^2 \), and \( h(x) = -4x^2 \) on one screen. Write a short sentence explaining what you learned in this exercise.

3. Use your graphing calculator to sketch the graphs of \( f(x) = x^2 \), \( g(x) = (x - 2)^2 \), and \( h(x) = (x - 4)^2 \) on one screen. Write a short sentence explaining what you learned in this exercise.

4. Use your graphing calculator to sketch the graphs of \( f(x) = x^2 \), \( g(x) = (x + 2)^2 \), and \( h(x) = (x + 4)^2 \) on one screen. Write a short sentence explaining what you learned in this exercise.

5. Use your graphing calculator to sketch the graphs of \( f(x) = x^2 \), \( g(x) = x^2 + 2 \), and \( h(x) = x^2 + 4 \) on one screen. Write a short sentence explaining what you learned in this exercise.

6. Use your graphing calculator to sketch the graphs of \( f(x) = x^2 \), \( g(x) = x^2 - 2 \), and \( h(x) = x^2 - 4 \) on one screen. Write a short sentence explaining what you learned in this exercise.

In Exercises 7-14, write down the given quadratic function on your homework paper, then state the coordinates of the vertex.

7. \( f(x) = -5(x - 4)^2 - 5 \)

8. \( f(x) = 5(x + 3)^2 - 7 \)

9. \( f(x) = 3(x + 1)^2 \)

10. \( f(x) = \frac{7}{5} \left( x + \frac{5}{9} \right)^2 - \frac{3}{4} \)

11. \( f(x) = -7(x - 4)^2 + 6 \)

12. \( f(x) = -\frac{1}{2} \left( x - \frac{8}{9} \right)^2 + \frac{2}{9} \)

13. \( f(x) = \frac{1}{6} \left( x + \frac{7}{3} \right)^2 + \frac{3}{8} \)

14. \( f(x) = -\frac{3}{2} \left( x + \frac{1}{2} \right)^2 - \frac{8}{9} \)

In Exercises 15-22, state the equation of the axis of symmetry of the graph of the given quadratic function.

15. \( f(x) = -7(x - 3)^2 + 1 \)

16. \( f(x) = -6(x + 8)^2 + 1 \)

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17. \[ f(x) = -\frac{7}{8} \left( x + \frac{1}{4} \right)^2 + \frac{2}{3} \]

18. \[ f(x) = -\frac{1}{2} \left( x - \frac{3}{8} \right)^2 - \frac{5}{7} \]

19. \[ f(x) = -\frac{2}{9} \left( x + \frac{2}{3} \right)^2 - \frac{4}{5} \]

20. \[ f(x) = -7(x + 3)^2 + 9 \]

21. \[ f(x) = -\frac{8}{7} \left( x + \frac{2}{9} \right)^2 + \frac{6}{5} \]

22. \[ f(x) = 3(x + 3)^2 + 6 \]

In Exercises 23-36, perform each of the following tasks for the given quadratic function.

i. Set up a coordinate system on graph paper. Label and scale each axis.

ii. Plot the vertex of the parabola and label it with its coordinates.

iii. Draw the axis of symmetry and label it with its equation.

iv. Set up a table near your coordinate system that contains exact coordinates of two points on either side of the axis of symmetry. Plot them on your coordinate system and their “mirror images” across the axis of symmetry.

v. Sketch the parabola and label it with its equation.

vi. Use interval notation to describe both the domain and range of the quadratic function.

23. \[ f(x) = (x + 2)^2 - 3 \]

24. \[ f(x) = (x - 3)^2 - 4 \]

25. \[ f(x) = -(x - 2)^2 + 5 \]

26. \[ f(x) = -(x + 4)^2 + 4 \]

27. \[ f(x) = (x - 3)^2 \]

28. \[ f(x) = -(x + 2)^2 \]

29. \[ f(x) = -x^2 + 7 \]

30. \[ f(x) = -x^2 + 7 \]

31. \[ f(x) = 2(x - 1)^2 - 6 \]

32. \[ f(x) = -2(x + 1)^2 + 5 \]

33. \[ f(x) = -\frac{1}{2}(x + 1)^2 + 5 \]

34. \[ f(x) = \frac{1}{2}(x - 3)^2 - 6 \]

35. \[ f(x) = 2(x - 5/2)^2 - 15/2 \]

36. \[ f(x) = -3(x + 7/2)^2 + 15/4 \]

In Exercises 37-44, write the given quadratic function on your homework paper, then use set-builder and interval notation to describe the domain and the range of the function.

37. \[ f(x) = 7(x + 6)^2 - 6 \]

38. \[ f(x) = 8(x + 1)^2 + 7 \]

39. \[ f(x) = -3(x + 4)^2 - 7 \]

40. \[ f(x) = -6(x - 7)^2 + 9 \]

41. \[ f(x) = -7(x + 5)^2 - 7 \]

42. \[ f(x) = 8(x - 4)^2 + 3 \]

43. \[ f(x) = -4(x - 1)^2 + 2 \]

44. \[ f(x) = 7(x - 2)^2 - 3 \]

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In Exercises 45-52, using the given value of $a$, find the specific quadratic function of the form $f(x) = a(x - h)^2 + k$ that has the graph shown. Note: $h$ and $k$ are integers. Check your solution with your graphing calculator.

45. $a = -2$

46. $a = 0.5$

47. $a = 2$

48. $a = 0.5$

49. $a = 2$

50. $a = -0.5$
51. \( a = 2 \)

\[
\begin{align*}
\text{(Graph of a parabola opening upward with vertex at (0, 0).)}
\end{align*}
\]

52. \( a = 0.5 \)

\[
\begin{align*}
\text{(Graph of a parabola opening downward with vertex at (0, 0).)}
\end{align*}
\]

In Exercises 53-54, use the graph to determine the range of the function \( f(x) = ax^2 + bx + c \). The arrows on the graph are meant to indicate that the graph continues indefinitely in the continuing pattern and direction of each arrow. Describe your solution using interval notation.

53.

\[
\begin{align*}
\text{(Graph of a parabola opening downward with vertex at (0, 0).)}
\end{align*}
\]

54.

\[
\begin{align*}
\text{(Graph of a parabola opening upward with vertex at (0, 0).)}
\end{align*}
\]

55.

\[
\begin{align*}
\text{(Graph of a parabola opening upward with vertex at (0, 0).)}
\end{align*}
\]

In Exercises 55-56, use the graph to determine the domain of the function \( f(x) = ax^2 + bx + c \). The arrows on the graph are meant to indicate that the graph continues indefinitely in the continuing pattern and direction of each arrow. Use interval notation to describe your solution.

55.

\[
\begin{align*}
\text{(Graph of a parabola opening downward with vertex at (0, 0).)}
\end{align*}
\]

56.

\[
\begin{align*}
\text{(Graph of a parabola opening upward with vertex at (0, 0).)}
\end{align*}
\]
5.1 Answers


3. The graph of \( g(x) = (x-2)^2 \) is shifted 2 units to the right of \( f(x) = x^2 \). The graph of \( h(x) = (x-4)^2 \) is shifted 4 units to the right of \( f(x) = x^2 \).

5. The graph of \( g(x) = x^2 + 2 \) is shifted 2 units to the upward from the graph of \( f(x) = x^2 \). The graph of \( h(x) = x^2 + 4 \) is shifted 4 units upward from the graph of \( f(x) = x^2 \).

7. \((4, -5)\)

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

11. \((4, 6)\)

13. \(\left(-\frac{7}{3}, \frac{3}{8}\right)\)

15. \(x = 3\)

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

19. \(x = -\frac{2}{3}\)

21. \(x = -\frac{2}{9}\)
23. Domain $= (-\infty, \infty)$; Range $= [-3, \infty)$  

\[
f(x) = (x+2)^2 - 3
\]

29. Domain $= (-\infty, \infty)$; Range $= (-\infty, 7]$

\[
f(x) = -x^2 + 7
\]

25. Domain $= (-\infty, \infty)$; Range $= (-\infty, 5]\n
\[
f(x) = -(x-2)^2 + 5
\]

31. Domain $= (-\infty, \infty)$; Range $= [-6, \infty)$

\[
f(x) = 2(x-1)^2 - 6
\]

27. Domain $= (-\infty, \infty)$; Range $= [0, \infty)$

\[
f(x) = (x-3)^2
\]

33. Domain $= (-\infty, \infty)$; Range $= (-\infty, 5]\n
\[
f(x) = -\frac{1}{2}(x+1)^2 + 5
\]
35. Domain: \((-\infty, \infty)\); Range: \([-15/2, \infty)\)

37. Domain: \((-\infty, \infty)\); Range: \([-6, \infty) = \{y : y \geq -6\}\)

39. Domain: \((-\infty, \infty)\); Range: \((-\infty, -7] = \{y : y \leq -7\}\)

41. Domain: \((-\infty, \infty)\); Range: \((-\infty, -7] = \{y : y \leq -7\}\)

43. Domain: \((-\infty, \infty)\); Range: \((-\infty, 2]\ = \{y : y \leq 2\}\)

45. \(f(x) = -2(x - 3)^2 + 1\)

47. \(f(x) = 2(x + 1)^2 - 1\)

49. \(f(x) = 2(x + 2)^2 + 1\)

51. \(f(x) = 2(x - 3)^2 - 1\)

53. \((-\infty, -2]\)

55. \((-\infty, \infty)\)
5.2 Exercises

In Exercises 1-8, expand the binomial.

1. \((x + \frac{4}{5})^2\)
2. \((x - \frac{4}{5})^2\)
3. \((x + 3)^2\)
4. \((x + 5)^2\)
5. \((x - 7)^2\)
6. \((x - \frac{2}{5})^2\)
7. \((x - 6)^2\)
8. \((x - \frac{5}{2})^2\)

In Exercises 9-16, factor the perfect square trinomial.

9. \(x^2 - \frac{6}{5}x + \frac{9}{25}\)
10. \(x^2 + 5x + \frac{25}{4}\)
11. \(x^2 - 12x + 36\)
12. \(x^2 + 3x + \frac{9}{4}\)
13. \(x^2 + 12x + 36\)
14. \(x^2 - \frac{3}{2}x + \frac{9}{16}\)
15. \(x^2 + 18x + 81\)
16. \(x^2 + 10x + 25\)

In Exercises 17-24, transform the given quadratic function into vertex form \(f(x) = (x - h)^2 + k\) by completing the square.

17. \(f(x) = x^2 - x + 8\)
18. \(f(x) = x^2 + x - 7\)
19. \(f(x) = x^2 - 5x - 4\)
20. \(f(x) = x^2 + 7x - 1\)
21. \(f(x) = x^2 + 2x - 6\)
22. \(f(x) = x^2 + 4x + 8\)
23. \(f(x) = x^2 - 9x + 3\)
24. \(f(x) = x^2 - 7x + 8\)

In Exercises 25-32, transform the given quadratic function into vertex form \(f(x) = a(x - h)^2 + k\) by completing the square.

25. \(f(x) = -2x^2 - 9x - 3\)
26. \(f(x) = -4x^2 - 6x + 1\)
27. \(f(x) = 5x^2 + 5x + 5\)
28. \(f(x) = 3x^2 - 4x - 6\)
29. \(f(x) = 5x^2 + 7x - 3\)
30. \(f(x) = 5x^2 + 6x + 4\)
31. \(f(x) = -x^2 - x + 4\)
32. \(f(x) = -3x^2 - 6x + 4\)

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In Exercises 33-38, find the vertex of the graph of the given quadratic function.

33. \( f(x) = -2x^2 + 5x + 3 \)
34. \( f(x) = x^2 + 5x + 8 \)
35. \( f(x) = -4x^2 - 4x + 1 \)
36. \( f(x) = 5x^2 + 7x + 8 \)
37. \( f(x) = 4x^2 + 2x + 8 \)
38. \( f(x) = x^2 + x - 7 \)

In Exercises 39-44, find the axis of symmetry of the graph of the given quadratic function.

39. \( f(x) = -5x^2 - 7x - 8 \)
40. \( f(x) = x^2 + 6x + 3 \)
41. \( f(x) = -2x^2 - 5x - 8 \)
42. \( f(x) = -x^2 - 6x + 2 \)
43. \( f(x) = -5x^2 + x + 6 \)
44. \( f(x) = x^2 - 9x - 6 \)

For each of the quadratic functions in Exercises 45-66, perform each of the following tasks.

i. Use the technique of completing the square to place the given quadratic function in vertex form.

ii. Set up a coordinate system on a sheet of graph paper. Label and scale each axis.

iii. Draw the axis of symmetry and label it with its equation. Plot the vertex and label it with its coordinates.

iv. Set up a table near your coordinate system that calculates the coordinates of two points on either side of the axis of symmetry. Plot these points and their mirror images across the axis of symmetry. Draw the parabola and label it with its equation.

v. Use the graph of the parabola to determine the domain and range of the quadratic function. Describe the domain and range using interval notation.

45. \( f(x) = x^2 - 8x + 12 \)
46. \( f(x) = x^2 + 4x - 1 \)
47. \( f(x) = x^2 + 6x + 3 \)
48. \( f(x) = x^2 - 4x + 1 \)
49. \( f(x) = x^2 - 2x - 6 \)
50. \( f(x) = x^2 + 10x + 23 \)
51. \( f(x) = -x^2 + 6x - 4 \)
52. \( f(x) = -x^2 - 6x - 3 \)
53. \( f(x) = -x^2 - 10x - 21 \)
54. \( f(x) = -x^2 + 12x - 33 \)
55. \( f(x) = 2x^2 - 8x + 3 \)
56. \( f(x) = 2x^2 + 8x + 4 \)
57. \( f(x) = -2x^2 - 12x - 13 \)
58. \( f(x) = -2x^2 + 24x - 70 \)
59. \( f(x) = (1/2)x^2 - 4x + 5 \)
60. \( f(x) = (1/2)x^2 + 4x + 6 \)
61. \( f(x) = (-1/2)x^2 - 3x + 1/2 \)
62. \( f(x) = (-1/2)x^2 + 4x - 2 \)
63. \( f(x) = 2x^2 + 7x - 2 \)
64. \( f(x) = -2x^2 - 5x - 4 \)
65. \( f(x) = -3x^2 + 8x - 3 \)
66. \( f(x) = 3x^2 + 4x - 6 \)

In **Exercises 67-72**, find the range of the given quadratic function. Express your answer in both interval and set notation.

67. \( f(x) = -2x^2 + 4x + 3 \)
68. \( f(x) = x^2 + 4x + 8 \)
69. \( f(x) = 5x^2 + 4x + 4 \)
70. \( f(x) = 3x^2 - 8x + 3 \)
71. \( f(x) = -x^2 - 2x - 7 \)
72. \( f(x) = x^2 + x + 9 \)

**Drill for Skill.** In **Exercises 73-76**, evaluate the function at the given value \( b \).

73. \( f(x) = 9x^2 - 9x + 4; \ b = -6 \)
74. \( f(x) = -12x^2 + 5x + 2; \ b = -3 \)
75. \( f(x) = 4x^2 - 6x - 4; \ b = 11 \)
76. \( f(x) = -2x^2 - 11x - 10; \ b = -12 \)

**Drill for Skill.** In **Exercises 77-80**, evaluate the function at the given expression.

77. Evaluate \( f(x+4) \) if \( f(x) = -5x^2 + 4x + 2 \).
78. Evaluate \( f(-4x-5) \) if \( f(x) = 4x^2 + x + 1 \).
5.2 Answers

1. \( x^2 + \frac{8}{5}x + \frac{16}{25} \)
2. \( x^2 + 8x + 16 \)
3. \( x^2 + 6x + 9 \)
4. \( x^2 - 14x + 49 \)
5. \( x^2 - 12x + 36 \)
6. \( x^2 - 10x + 25 \)
7. \( x^2 - 12x + 36 \)
8. \( x^2 - 12x + 36 \)
9. \( (x - \frac{3}{5})^2 \)
10. \( (x - 6)^2 \)
11. \( (x - 6)^2 \)
12. \( (x + 6)^2 \)
13. \( (x + 6)^2 \)
14. \( (x + 9)^2 \)
15. \( (x + 9)^2 \)
16. \( (x - \frac{3}{2})^2 + \frac{1}{4} \)
17. \( (x - 2)^2 + 3 \)
18. \( (x - 5)^2 - \frac{41}{4} \)
19. \( (x + 1)^2 - 7 \)
20. \( (x - \frac{9}{2})^2 - \frac{69}{4} \)
21. \( (x + 1)^2 - 7 \)
22. \( (x + 4)^2 - 8 \)
23. \( (x + 4)^2 - 8 \)
24. \( (x - \frac{9}{2})^2 - \frac{69}{4} \)
25. \( -2 \left( x + \frac{9}{4} \right)^2 + \frac{57}{8} \)
26. \( 5 \left( x + \frac{1}{2} \right)^2 + \frac{15}{4} \)
27. \( 5 \left( x + \frac{7}{10} \right)^2 - \frac{109}{20} \)
28. \( 5 \left( x + \frac{1}{2} \right)^2 + \frac{17}{4} \)
29. \( 5 \left( x + \frac{1}{2} \right)^2 + \frac{17}{4} \)
30. \( \left( \frac{5}{4}, \frac{49}{8} \right) \)
31. \( \left( \frac{5}{4}, \frac{49}{8} \right) \)
32. \( \left( \frac{5}{4}, \frac{49}{8} \right) \)
33. \( \left( \frac{5}{4}, \frac{49}{8} \right) \)
34. \( \left( \frac{5}{4}, \frac{49}{8} \right) \)
35. \( \left( -\frac{1}{2}, 2 \right) \)
36. \( \left( \frac{1}{4}, \frac{31}{4} \right) \)
37. \( \left( -\frac{7}{10} \right) \)
38. \( \left( \frac{5}{4} \right) \)
39. \( \left( x = -\frac{7}{10} \right) \)
40. \( \left( x = \frac{5}{4} \right) \)
41. \( \left( x = \frac{1}{10} \right) \)
42. \( \left( \frac{1}{10} \right) \)
43. \( \left( \frac{1}{10} \right) \)
44. \( \left( \frac{1}{10} \right) \)
45. \( f(x) = (x - 4)^2 - 4 \)

Domain = \( \mathbb{R} \), Range = \( [-4, \infty) \)
47. \[ f(x) = (x + 3)^2 - 6 \]

Domain = \( \mathbb{R} \), Range = \([-6, \infty)\)

49. \[ f(x) = (x - 1)^2 - 7 \]

Domain = \( \mathbb{R} \), Range = \([-7, \infty)\)

51. \[ f(x) = -(x - 3)^2 + 5 \]

Domain = \( \mathbb{R} \), Range = \((-\infty, 5]\)

53. \[ f(x) = -(x + 5)^2 + 4 \]

Domain = \( \mathbb{R} \), Range = \((-\infty, 4]\)
55. \( f(x) = 2(x - 2)^2 - 5 \)

\[ f(x) = 2(x - 2)^2 - 5 \]

Domain = \( \mathbb{R} \), Range = \([-5, \infty)\)

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

\[ f(x) = -2(x + 3)^2 + 5 \]

Domain = \( \mathbb{R} \), Range = \((-\infty, 5]\)

59. \( f(x) = \frac{1}{2}(x - 4)^2 - 3 \)

\[ f(x) = \frac{1}{2}(x - 4)^2 - 3 \]

Domain = \( \mathbb{R} \), Range = \([-3, \infty)\)

61. \( f(x) = \frac{-1}{2}(x + 3)^2 + 5 \)

\[ f(x) = \frac{-1}{2}(x + 3)^2 + 5 \]

Domain = \( \mathbb{R} \), Range = \((-\infty, 5]\)
63. \( f(x) = 2(x + \frac{7}{4})^2 - \frac{65}{8} \)

\[
\begin{align*}
\text{Domain} &= \mathbb{R}, \quad \text{Range} = [-\frac{65}{8}, \infty)
\end{align*}
\]

65. \( f(x) = -3(x - \frac{4}{3})^2 + \frac{7}{3} \)

\[
\begin{align*}
\text{Domain} &= \mathbb{R}, \quad \text{Range} = (-\infty, \frac{7}{3})
\end{align*}
\]

67. \( (-\infty, 5] = \{ x | x \leq 5 \} \)

69. \( \left[ \frac{16}{5}, \infty \right) = \{ x | x \geq \frac{16}{5} \} \)

71. \( (-\infty, -6] = \{ x | x \leq -6 \} \)

73. 382

75. 414

77. \(-5x^2 - 36x - 62\)

79. \(64x^2 - 20x - 2\)
5.3 Exercises

In Exercises 1-8, factor the given quadratic polynomial.

1. \( x^2 + 9x + 14 \)
2. \( x^2 + 6x + 5 \)
3. \( x^2 + 10x + 9 \)
4. \( x^2 + 4x - 9 \)
5. \( x^2 - 4x - 5 \)
6. \( x^2 + 7x - 8 \)
7. \( x^2 - 7x + 12 \)
8. \( x^2 + 5x - 24 \)

In Exercises 9-16, find the zeros of the given quadratic function.

9. \( f(x) = x^2 - 2x - 15 \)
10. \( f(x) = x^2 + 4x - 32 \)
11. \( f(x) = x^2 + 10x - 39 \)
12. \( f(x) = x^2 + 4x - 45 \)
13. \( f(x) = x^2 - 14x + 40 \)
14. \( f(x) = x^2 - 5x - 14 \)
15. \( f(x) = x^2 + 9x - 36 \)
16. \( f(x) = x^2 + 11x - 26 \)

In Exercises 17-22, perform each of the following tasks for the quadratic functions.

i. Load the function into \( Y1 \) of the \( Y= \) of your graphing calculator. Adjust the window parameters so that the vertex is visible in the viewing window.

ii. Set up a coordinate system on your homework paper. Label and scale each axis with \( x_{\text{min}}, x_{\text{max}}, y_{\text{min}}, \) and \( y_{\text{max}} \). Make a reasonable copy of the image in the viewing window of your calculator on this coordinate system and label it with its equation.

iii. Use the zero utility on your graphing calculator to find the zeros of the function. Use these results to plot the \( x \)-intercepts on your coordinate system and label them with their coordinates.

iv. Use a strictly algebraic technique (no calculator) to find the zeros of the given quadratic function. Show your work next to your coordinate system. Be stubborn! Work the problem until your algebraic and graphically zeros a reasonable match.

17. \( f(x) = x^2 + 5x - 14 \)
18. \( f(x) = x^2 + x - 20 \)
19. \( f(x) = -x^2 + 3x + 18 \)
20. \( f(x) = -x^2 + 3x + 40 \)
21. \( f(x) = x^2 - 16x - 36 \)
22. \( f(x) = x^2 + 4x - 96 \)

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In Exercises 23-30, perform each of the following tasks for the given quadratic function.

i. Set up a coordinate system on graph paper. Label and scale each axis. Remember to draw all lines with a ruler.

ii. Use the technique of completing the square to place the quadratic function in vertex form. Plot the vertex on your coordinate system and label it with its coordinates. Draw the axis of symmetry on your coordinate system and label it with its equation.

iii. Use a strictly algebraic technique (no calculators) to find the x-intercepts of the graph of the given quadratic function. Plot them on your coordinate system and label them with their coordinates.

iv. Find the y-intercept of the graph of the quadratic function. Plot the y-intercept on your coordinate system and its mirror image across the axis of symmetry, then label these points with their coordinates.

v. Using all the information plotted, draw the graph of the quadratic function and label it with the vertex form of its equation. Use interval notation to describe the domain and range of the quadratic function.

23. \( f(x) = x^2 + 2x - 8 \)
24. \( f(x) = x^2 - 6x + 8 \)
25. \( f(x) = x^2 + 4x - 12 \)
26. \( f(x) = x^2 + 8x + 12 \)
27. \( f(x) = -x^2 - 2x + 8 \)
28. \( f(x) = -x^2 - 2x + 24 \)
29. \( f(x) = -x^2 - 8x + 48 \)

30. \( f(x) = -x^2 - 8x + 20 \)

In Exercises 31-38, factor the given quadratic polynomial.

31. \( 42x^2 + 5x - 2 \)
32. \( 3x^2 + 7x - 20 \)
33. \( 5x^2 - 19x + 12 \)
34. \( 54x^2 - 3x - 1 \)
35. \( -4x^2 + 9x - 5 \)
36. \( 3x^2 - 5x - 12 \)
37. \( 2x^2 - 3x - 35 \)
38. \( -6x^2 + 25x + 9 \)

In Exercises 39-46, find the zeros of the given quadratic functions.

39. \( f(x) = 2x^2 - 3x - 20 \)
40. \( f(x) = 2x^2 - 7x - 30 \)
41. \( f(x) = -2x^2 + x + 28 \)
42. \( f(x) = -2x^2 + 15x - 22 \)
43. \( f(x) = 3x^2 - 20x + 12 \)
44. \( f(x) = 4x^2 + 11x - 20 \)
45. \( f(x) = -4x^2 + 4x + 15 \)
46. \( f(x) = -6x^2 - x + 12 \)

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In Exercises 47-52, perform each of the following tasks for the given quadratic functions.

i. Load the function into Y1 of the Y= of your graphing calculator. Adjust the window parameters so that the vertex is visible in the viewing window.

ii. Set up a coordinate system on your homework paper. Label and scale each axis with xmin, xmax, ymin, and ymax. Make a reasonable copy of the image in the viewing window of your calculator on this coordinate system and label it with its equation.

iii. Use the zero utility on your graphing calculator to find the zeros of the function. Use these results to plot the x-intercepts on your coordinate system and label them with their coordinates.

iv. Use a strictly algebraic technique (no calculator) to find the zeros of the given quadratic function. Show your work next to your coordinate system. Be stubborn! Work the problem until your algebraic and graphically zeros are a reasonable match.

47. \( f(x) = 2x^2 + 3x - 35 \)

48. \( f(x) = 2x^2 - 5x - 42 \)

49. \( f(x) = -2x^2 + 5x + 33 \)

50. \( f(x) = -2x^2 - 5x + 52 \)

51. \( f(x) = 4x^2 - 24x - 13 \)

52. \( f(x) = 4x^2 + 24x - 45 \)

In Exercises 53-60, perform each of the following tasks for the given quadratic functions.

i. Set up a coordinate system on graph paper. Label and scale each axis. Remember to draw all lines with a ruler.

ii. Use the technique of completing the square to place the quadratic function in vertex form. Plot the vertex on your coordinate system and label it with its coordinates. Draw the axis of symmetry on your coordinate system and label it with its equation.

iii. Use a strictly algebraic method (no calculators) to find the x-intercepts of the graph of the quadratic function. Plot them on your coordinate system and label them with their coordinates.

iv. Find the y-intercept of the graph of the quadratic function. Plot the y-intercept on your coordinate system and its mirror image across the axis of symmetry, then label these points with their coordinates.

v. Using all the information plotted, draw the graph of the quadratic function and label it with the vertex form of its equation. Use interval notation to describe the domain and range of the quadratic function.

53. \( f(x) = 2x^2 - 8x - 24 \)

54. \( f(x) = 2x^2 - 4x - 6 \)

55. \( f(x) = -2x^2 - 4x + 16 \)

56. \( f(x) = -2x^2 - 16x + 40 \)

57. \( f(x) = 3x^2 + 18x - 48 \)

58. \( f(x) = 3x^2 + 18x - 216 \)

59. \( f(x) = 2x^2 + 10x - 48 \)

60. \( f(x) = 2x^2 - 10x - 100 \)
In Exercises 61-66, Use the graph of 
\( f(x) = ax^2 + bx + c \) shown to find all solutions of the equation \( f(x) = 0 \). (Note: Every solution is an integer.)

**61.**

![Graph 1](image1.png)

**62.**

![Graph 2](image2.png)

**63.**

![Graph 3](image3.png)

**64.**

![Graph 4](image4.png)

**65.**

![Graph 5](image5.png)

**66.**

![Graph 6](image6.png)
5.3 Answers

1. \((x + 2)(x + 7)\)
3. \((x + 9)(x + 1)\)
5. \((x - 5)(x + 1)\)
7. \((x - 4)(x - 3)\)
9. Zeros: \(x = -3, x = 5\)
11. Zeros: \(x = -13, x = 3\)
13. Zeros: \(x = 4, x = 10\)
15. Zeros: \(x = -12, x = 3\)

17.

19.

21.
23. Domain = \((-\infty, \infty)\),
Range = \([-9, \infty)\)

27. Domain = \((-\infty, \infty)\),
Range = \((-\infty, 9]\)

25. Domain = \((-\infty, \infty)\),
Range = \([-16, \infty)\)

29. Domain = \((-\infty, \infty)\),
Range = \((-\infty, 64]\)

31. \((7x + 2)(6x - 1)\)

33. \((x - 3)(5x - 4)\)

35. \((4x - 5)(-x + 1)\)

37. \((2x + 7)(x - 5)\)

39. Zeros: \(x = -5/2, x = 4\)

41. Zeros: \(x = -7/2, x = 4\)

43. Zeros: \(x = 2/3, x = 6\)
45. Zeros: $x = -\frac{3}{2}, x = \frac{5}{2}$

47.

51.

53. Domain $= (-\infty, \infty), \quad$ Range $= [-32, \infty)$

55. Domain $= (-\infty, \infty), \quad$ Range $= (-\infty, 18]$
57. Domain = (−∞, ∞),
Range = [−75, ∞)

\[ f(x) = 3(x+3)^2 - 75 \]

61. −2, 3

59. Domain = (−∞, ∞),
Range = [−121/2, ∞)

\[ f(x) = 2(x+5/2)^2 - 121/2 \]


5.4 Exercises

In Exercises 1-8, find all real solutions of the given equation. Use a calculator to approximate the answers, correct to the nearest hundredth (two decimal places).

1.  $x^2 = 36$
2.  $x^2 = 81$
3.  $x^2 = 17$
4.  $x^2 = 13$
5.  $x^2 = 0$
6.  $x^2 = -18$
7.  $x^2 = -12$
8.  $x^2 = 3$

In Exercises 9-16, find all real solutions of the given equation. Use a calculator to approximate your answers to the nearest hundredth.

9.  $(x - 1)^2 = 25$
10.  $(x + 3)^2 = 9$
11.  $(x + 2)^2 = 0$
12.  $(x - 3)^2 = -9$
13.  $(x + 6)^2 = -81$
14.  $(x + 7)^2 = 10$
15.  $(x - 8)^2 = 15$
16.  $(x + 10)^2 = 37$

In Exercises 17-28, perform each of the following tasks for the given quadratic function.

i. Set up a coordinate system on a sheet of graph paper. Label and scale each axis. Remember to draw all lines with a ruler.

ii. Place the quadratic function in vertex form. Plot the vertex on your coordinate system and label it with its coordinates. Draw the axis of symmetry on your coordinate system and label it with its equation.

iii. Use the quadratic formula to find the $x$-intercepts of the parabola. Use a calculator to approximate each intercept, correct to the nearest tenth, and use these approximations to plot the $x$-intercepts on your coordinate system. However, label each $x$-intercept with its exact coordinates.

iv. Plot the $y$-intercept on your coordinate system and its mirror image across the axis of symmetry and label each with their coordinates.

v. Using all of the information on your coordinate system, draw the graph of the parabola, then label it with the vertex form of the function. Use interval notation to state the domain and range of the quadratic function.

17.  $f(x) = x^2 - 4x - 8$
18.  $f(x) = x^2 + 6x - 1$
19.  $f(x) = x^2 + 6x - 3$
20.  $f(x) = x^2 - 8x + 1$
21.  $f(x) = -x^2 + 2x + 10$

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22. \( f(x) = -x^2 - 8x - 8 \)
23. \( f(x) = -x^2 - 8x - 9 \)
24. \( f(x) = -x^2 + 10x - 20 \)
25. \( f(x) = 2x^2 - 20x + 40 \)
26. \( f(x) = 2x^2 - 16x + 12 \)
27. \( f(x) = -2x^2 + 16x + 8 \)
28. \( f(x) = -2x^2 - 24x - 52 \)

In Exercises 29-32, perform each of the following tasks for the given quadratic equation.

i. Set up a coordinate system on a sheet of graph paper. Label and scale each axis. Remember to draw all lines with a ruler.

ii. Show that the discriminant is negative.

iii. Use the technique of completing the square to put the quadratic function in vertex form. Plot the vertex on your coordinate system and label it with its coordinates. Draw the axis of symmetry on your coordinate system and label it with its equation.

iv. Plot the \( y \)-intercept and its mirror image across the axis of symmetry on your coordinate system and label each with their coordinates.

v. Because the discriminant is negative (did you remember to show that?), there are no \( x \)-intercepts. Use the given equation to calculate one additional point, then plot the point and its mirror image across the axis of symmetry and label each with their coordinates.

vi. Using all of the information on your coordinate system, draw the graph of the parabola, then label it with the vertex form of function. Use interval notation to describe the domain and range of the quadratic function.

29. \( f(x) = x^2 + 4x + 8 \)
30. \( f(x) = x^2 - 4x + 9 \)
31. \( f(x) = -x^2 + 6x - 11 \)
32. \( f(x) = -x^2 - 8x - 20 \)

In Exercises 33-36, perform each of the following tasks for the given quadratic function.

i. Set up a coordinate system on a sheet of graph paper. Label and scale each axis. Remember to draw all lines with a ruler.

ii. Use the discriminant to help determine the value of \( k \) so that the graph of the given quadratic function has exactly one \( x \)-intercept.

iii. Substitute this value of \( k \) back into the given quadratic function, then use the technique of completing the square to put the quadratic function in vertex form. Plot the vertex on your coordinate system and label it with its coordinates. Draw the axis of symmetry on your coordinate system and label it with its equation.

iv. Plot the \( y \)-intercept and its mirror image across the axis of symmetry and label each with their coordinates.

v. Use the equation to calculate an additional point on either side of the axis of symmetry, then plot this point and its mirror image across the axis of symmetry and label each with their coordinates.

vi. Using all of the information on your coordinate system, draw the graph of the parabola, then label it with the vertex form of the function. Use
interval notation to describe the domain and range of the quadratic function.

33. \( f(x) = x^2 - 4x + 4k \)
34. \( f(x) = x^2 + 6x + 3k \)
35. \( f(x) = kx^2 - 16x - 32 \)
36. \( f(x) = kx^2 - 24x + 48 \)

37. Find all values of \( k \) so that the graph of the quadratic function \( f(x) = kx^2 - 3x + 5 \) has exactly two \( x \)-intercepts.

38. Find all values of \( k \) so that the graph of the quadratic function \( f(x) = 2x^2 + 7x - 4k \) has exactly two \( x \)-intercepts.

39. Find all values of \( k \) so that the graph of the quadratic function \( f(x) = 2x^2 - x + 5k \) has no \( x \)-intercepts.

40. Find all values of \( k \) so that the graph of the quadratic function \( f(x) = kx^2 - 2x - 4 \) has no \( x \)-intercepts.

In Exercises 41-50, find all real solutions, if any, of the equation \( f(x) = b \).

41. \( f(x) = 63x^2 + 74x - 1; b = 8 \)
42. \( f(x) = 64x^2 + 128x + 64; b = 0 \)
43. \( f(x) = x^2 - x - 5; b = 2 \)
44. \( f(x) = 5x^2 - 5x; b = 3 \)
45. \( f(x) = 4x^2 + 4x - 1; b = -2 \)
46. \( f(x) = 2x^2 - 9x - 3; b = -1 \)
47. \( f(x) = 2x^2 + 4x + 6; b = 0 \)
48. \( f(x) = 24x^2 - 54x + 27; b = 0 \)
49. \( f(x) = -3x^2 + 2x - 13; b = -5 \)
50. \( f(x) = x^2 - 5x - 7; b = 0 \)

In Exercises 51-60, find all real solutions, if any, of the quadratic equation.

51. \(-2x^2 + 7 = -3x\)
52. \(-x^2 = -9x + 7\)
53. \(x^2 - 2 = -3x\)
54. \(81x^2 = -162x - 81\)
55. \(9x^2 + 81 = -54x\)
56. \(-30x^2 - 28 = -62x\)
57. \(-x^2 + 6 = 7x\)
58. \(-8x^2 = 4x + 2\)
59. \(4x^2 + 3 = -x\)
60. \(27x^2 = -66x + 16\)

In Exercises 61-66, find all of the \( x \)-intercepts, if any, of the given function.

61. \( f(x) = -4x^2 - 4x - 5 \)
62. \( f(x) = 49x^2 - 28x + 4 \)
63. \( f(x) = -56x^2 + 47x + 18 \)
64. \( f(x) = 24x^2 + 34x + 12 \)
65. \( f(x) = 36x^2 + 96x + 64 \)
66. \( f(x) = 5x^2 + 2x + 3 \)

In Exercises 67-74, determine the number of real solutions of the equation.

67. \( 9x^2 + 6x + 1 = 0 \)
68. \(7x^2 - 12x + 7 = 0\)
69. \(-6x^2 + 4x - 7 = 0\)
70. \(-8x^2 + 11x - 4 = 0\)
71. \(-5x^2 - 10x - 5 = 0\)
72. \(6x^2 + 11x + 2 = 0\)
73. \(-7x^2 - 4x + 5 = 0\)
74. \(6x^2 + 10x + 4 = 0\)
5.4 Answers

1. \( x = \pm 6 \)

3. \( x = \pm \sqrt{17} \approx \pm 4.12 \)

5. \( x = 0 \)

7. No real solutions.

9. \( x = -4 \) or \( x = 6 \)

11. \( x = -2 \)

13. No real solutions.

15. \( x = 8 \pm \sqrt{15} \approx 4.13, 11.87 \)

17. Domain = \((-\infty, \infty)\),
Range = \([-12, \infty)\)

19. Domain = \((-\infty, \infty)\),
Range = \([-12, \infty)\)

21. Domain = \((-\infty, \infty)\),
Range = \((-\infty, 11]\)

\[
\begin{align*}
\text{Graph 1:} & \quad f(x) = (x - 2)^2 - 12 \\
\text{Graph 2:} & \quad f(x) = (x + 3)^2 - 12 \\
\text{Graph 3:} & \quad f(x) = -(x - 1)^2 + 11
\end{align*}
\]
23. Domain = \((-\infty, \infty)\),
Range = \((-\infty, 7]\)

25. Domain = \((-\infty, \infty)\),
Range = \([-10, \infty)\)

27. Domain = \((-\infty, \infty)\),
Range = \((-\infty, 40]\)

29. Domain = \((-\infty, \infty)\),
Range = \([4, \infty)\)
31. Domain = \((-\infty, \infty)\),
    Range = \((-\infty, -2]\)

33. \(k = 1\), Domain = \((-\infty, \infty)\),
    Range = \([0, \infty)\)

35. \(k = -2\), Domain = \((-\infty, \infty)\),
    Range = \((-\infty, 0]\)

37. \(\{k : k < 9/20\}\)

39. \(\{k : k > 1/40\}\)

41. \(-9/7, 1/9\)

43. \(\frac{1+\sqrt{29}}{2}, \frac{1-\sqrt{29}}{2}\)

45. \(-\frac{1}{2}\)

47. no real solutions

49. no real solutions

51. \(\frac{3-\sqrt{65}}{4}, \frac{3+\sqrt{65}}{4}\)

53. \(-\frac{3-\sqrt{17}}{2}, -\frac{3+\sqrt{17}}{2}\)

55. \(-3\)

57. \(-\frac{7+\sqrt{73}}{2}, -\frac{7-\sqrt{73}}{2}\)

59. no real solutions

61. no \(x\)-intercepts

63. \((\frac{9}{8}, 0), (-\frac{2}{7}, 0)\)

65. \((-\frac{4}{3}, 0)\)
67. 1
69. 0
71. 1
73. 2
5.5 Exercises

In Exercises 1-12, write down the formula \( d = vt \) and solve for the unknown quantity in the problem. Once that is completed, substitute the known quantities in the result and simplify. Make sure to check that your units cancel and provide the appropriate units for your solution.

1. If Martha maintains a constant speed of 30 miles per hour, how far will she travel in 5 hours?

2. If Jamal maintains a constant speed of 25 miles per hour, how far will he travel in 5 hours?

3. If Arturo maintains a constant speed of 30 miles per hour, how long will it take him to travel 120 miles?

4. If Mei maintains a constant speed of 25 miles per hour, how long will it take her to travel 150 miles?

5. If Allen maintains a constant speed and travels 250 miles in 5 hours, what is his constant speed?

6. If Jane maintains a constant speed and travels 300 miles in 6 hours, what is her constant speed?

7. If Jose maintains a constant speed of 15 feet per second, how far will he travel in 5 minutes?

8. If Tami maintains a constant speed of 1.5 feet per second, how far will she travel in 4 minutes?

9. If Carmen maintains a constant speed of 80 meters per minute, how far will she travel in 600 seconds?

10. If Alphonso maintains a constant speed of 15 feet per second, how long will it take him to travel 1 mile? Note: 1 mile equals 5280 feet.

11. If Hoshi maintains a constant speed of 200 centimeters per second, how long will it take her to travel 20 meters? Note: 100 centimeters equals 1 meter.

12. If Maeko maintains a constant speed and travels 5 miles in 12 minutes, what is her speed in miles per hour?

In Exercises 13-18, a plot of speed \( v \) versus time \( t \) is presented.

i. Make an accurate duplication of the plot on graph paper. Label and scale each axis. Mark the units on each axis.

ii. Use the graph to determine the distance traveled over the time period \([0, 5]\), using the time units given on the graph.

13. 

![Graph](image)

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14. You’re told that a car moves with a constant acceleration of 7.5 ft/s². In your own words, explain what this means.

15. You’re told that an object will fall on a distant planet with constant acceleration 6.5 m/s². In your own words, explain what this means.

16. You’re told that the acceleration of a car is −18 ft/s². In your own words, explain what this means.
22. An observer on a distant planet throws an object into the air and as it moves upward he reports that the object has a constant acceleration of \(-4.5 \text{ m/s}^2\). In your own words, explain what this means.

In Exercises 23–28, perform each of the following tasks.

i. Solve the equation \(v = v_0 + at\) for the unknown quantity.
ii. Substitute the known quantities (with units) into your result, then simplify. Make sure the units cancel and provide appropriate units for your solution.

23. A rocket accelerates from rest with constant acceleration 15.8 m/s\(^2\). What will be the speed of the rocket after 3 minutes?

24. A stone is dropped from rest on a distant planet and it accelerates towards the ground with constant acceleration 3.8 ft/s\(^2\). What will be the speed of the stone after 2 minutes?

25. A stone is thrown downward on a distant planet with an initial speed of 20 ft/s. If the stone experiences constant acceleration of 32 ft/s\(^2\), what will be the speed of the stone after 1 minute?

26. A ball is hurled upward with an initial speed of 80 m/s. If the ball experiences a constant acceleration of \(-9.8 \text{ m/s}^2\), what will be the speed of the ball at the end of 5 seconds?

27. An object is shot into the air with an initial speed of 100 m/s. If the object experiences constant deceleration of 9.8 m/s\(^2\), how long will it take the ball to reach its maximum height?

28. An object is released from rest on a distant planet and after 5 seconds, its speed is 98 m/s. If the object falls with constant acceleration, determine the acceleration of the object.

In Exercises 29–42, use the appropriate equation of motion, either \(v = v_0 + at\) or \(x = x_0 + v_0t + (1/2)at^2\) or both, to solve the question posed in the exercise.

i. Select the appropriate equation of motion and solve for the unknown quantity.
ii. Substitute the known quantities (with their units) into your result and simplify. Check that cancellation of units provide units appropriate for your solution.
iii. Find a decimal approximation for your answer.

29. A rocket with initial velocity 30 m/s moves along a straight line with constant acceleration 2.5 m/s\(^2\). Find the velocity and the distance traveled by the rocket at the end of 10 seconds.

30. A car is traveling at 88 ft/s when it applies the brakes and begins to slow with constant deceleration of 5 ft/s\(^2\). What is its speed and how far has it traveled at the end of 5 seconds?

31. A car is traveling at 88 ft/s when it applies the brakes and slows to 58 ft/s in 10 seconds. Assuming constant deceleration, find the deceleration and the distance traveled by the car in the 10 second time interval. Hint: Compute the deceleration first.
32. A stone is hurled downward from above the surface of a distant planet with initial speed 45 m/s. At then end of 10 seconds, the velocity of the stone is 145 m/s. Assuming constant acceleration, find the acceleration of the stone and the distance traveled in the 10 second time period.

33. An object is shot into the air from the surface of the earth with an initial velocity of 180 ft/s. Find the maximum height of the object and the time it takes the object to reach that maximum height. Hint: The acceleration due to gravity near the surface of the earth is well known.

34. An object is shot into the air from the surface of a distant planet with an initial velocity of 180 m/s. Find the maximum height of the object and the time it takes the object to reach that maximum height. Assume that the acceleration due to gravity on this distant planet is 5.8 m/s². Hint: Calculate the time to the maximum height first.

35. A car is traveling down the highway at 55 mi/h when the driver spots a slide of rocks covering the road ahead and hits the brakes, providing a constant deceleration of 12 ft/s². How long does it take the car to come to a halt and how far does it travel during this time period?

36. A car is traveling down the highway in Germany at 81 km/h when the driver spots that traffic is stopped in the road ahead and hits the brakes, providing a constant deceleration of 2.3 m/s². How long does it take the car to come to a halt and how far does it travel during this time period? Note: 1 kilometer equals 1000 meters.

37. An object is released from rest at some distance over the surface of the earth. How far (in meters) will the object fall in 5 seconds and what will be its velocity at the end of this 5 second time period? Hint: You should know the acceleration due to gravity near the surface of the earth.

38. An object is released from rest at some distance over the surface of a distant planet. How far (in meters) will the object fall in 5 seconds and what will be its velocity at the end of this 5 second time period? Assume the acceleration due to gravity on the distant planet is 13.5 m/s².

39. An object is released from rest at a distance of 352 feet over the surface of the earth. How long will it take the object to impact the ground?

40. An object is released from rest at a distance of 400 meters over the surface of a distant planet. How long will it take the object to impact the ground? Assume that the acceleration due to gravity on the distant planet equals 5.3 m/s².

41. On earth, a ball is thrown upward from an initial height of 5 meters with an initial velocity of 100 m/s. How long will it take the ball to return to the ground?

42. On earth, a ball is thrown upward from an initial height of 5 feet with an initial velocity of 100 ft/s. How long will it take the ball to return to the ground?
A ball is thrown into the air near the surface of the earth. In Exercises 43-46, the initial height of the ball and the initial velocity of the ball are given. Complete the following tasks.

i. Use \( y = y_0 + v_0 t + (1/2)at^2 \) to set up a formula for the height \( y \) of the ball as a function of time \( t \). Use the appropriate constant for the acceleration due to gravity near the surface of the earth.

ii. Load the equation from the previous part into Y1 in your graphing calculator. Adjust your viewing window so that both the vertex and the time when the ball returns to the ground are visible. Copy the image onto your homework paper. Label and scale each axis with xmin, xmax, ymin, and ymax.

iii. Use the zero utility in the CALC menu of your graphing calculator to determine the time when the ball returns to the ground. Record this answer in the appropriate location on your graph.

iv. Use the quadratic formula to determine the time the ball returns to the ground. Use your calculator to find a decimal approximation of your solution. It should agree with that found using the zero utility on your graphing calculator. Be stubborn! Check your work until the answers agree.

43. \( y_0 = 50 \text{ ft}, v_0 = 120 \text{ ft/s} \).
44. \( y_0 = 30 \text{ m}, v_0 = 100 \text{ m/s} \).
45. \( y_0 = 20 \text{ m}, v_0 = 110 \text{ m/s} \).
46. \( y_0 = 100 \text{ ft}, v_0 = 200 \text{ ft/s} \).

47. A rock is thrown upward at an initial speed of 64 ft/s. How many seconds will it take the rock to rise 61 feet? Round your answer to the nearest hundredth of a second.

48. A penny is thrown downward from the top of a tree at an initial speed of 28 ft/s. How many seconds will it take the penny to fall 289 feet? Round your answer to the nearest hundredth of a second.

49. A water balloon is thrown downward from the roof of a building at an initial speed of 24 ft/s. The building is 169 feet tall. How many seconds will it take the water balloon to hit the ground? Round your answer to the nearest hundredth of a second.

50. A rock is thrown upward at an initial speed of 60 ft/s. How many seconds will it take the rock to rise 51 feet? Round your answer to the nearest hundredth of a second.

51. A ball is thrown upward from a height of 42 feet at an initial speed of 63 ft/s. How many seconds will it take the ball to hit the ground? Round your answer to the nearest hundredth of a second.

52. A rock is thrown upward from a height of 32 feet at an initial speed of 25 ft/s. How many seconds will it take the rock to hit the ground? Round your answer to the nearest hundredth of a second.
53. A penny is thrown downward from the top of a tree at an initial speed of 16 ft/s. The tree is 68 feet tall. How many seconds will it take the penny to hit the ground? Round your answer to the nearest hundredth of a second.

54. A penny is thrown downward off of the edge of a cliff at an initial speed of 32 ft/s. How many seconds will it take the penny to fall 210 feet? Round your answer to the nearest hundredth of a second.
5.5 Answers

1. 150 miles
3. 4 hours
5. 50 miles per hour
7. 4500 feet
9. 800 meters
11. 10 seconds
13. The distance traveled is 150 feet.

15. The distance traveled is 100 meters.

17. The distance traveled is 175 miles.

19. It means that the velocity of the car increases at a rate of 7.5 feet per second every second.

21. It means that the velocity of the car is decreasing at a rate of 18 feet per second every second.

23. 2,844 m/s
25. 1,940 ft/s
27. Approximately 10.2 seconds.

29. Velocity = 55 m/s,
Distance traveled = 425 m.

31. Acceleration = −3 ft/s²,
Distance traveled = 730 ft.

33. Time to max height = 5.625 s,
Max height = 506.25 ft.

35. Time to stop ≈ 6.72 s,
Distance traveled ≈ 271 ft.
37. Distance = 122.5 m, Velocity = −49 m/s.

39. Time ≈ 4.69 s

41. Time ≈ 20.5 s

43.

45.

47. 1.57 seconds

49. 2.59 seconds

51. 4.52 seconds

53. 1.62 seconds
5.6 **Exercises**

1. Find the exact maximum value of the function \( f(x) = -x^2 - 3x \).

2. Find the exact maximum value of the function \( f(x) = -x^2 - 5x - 2 \).

3. Find the vertex of the graph of the function \( f(x) = -3x^2 - 9x - 4 \).

4. Find the range of the function \( f(x) = -2x^2 - 9x + 2 \).

5. Find the exact maximum value of the function \( f(x) = -3x^2 - 9x - 4 \).

6. Find the equation of the axis of symmetry of the graph of the function \( f(x) = -x^2 - 5x - 9 \).

7. Find the vertex of the graph of the function \( f(x) = 3x^2 + 3x + 9 \).

8. Find the exact minimum value of the function \( f(x) = x^2 + x + 1 \).

9. Find the exact minimum value of the function \( f(x) = x^2 + 9x \).

10. Find the range of the function \( f(x) = 5x^2 - 3x - 4 \).

11. Find the range of the function \( f(x) = -3x^2 + 8x - 2 \).

12. Find the exact minimum value of the function \( f(x) = 2x^2 + 5x - 6 \).

13. Find the range of the function \( f(x) = 4x^2 + 9x - 8 \).

14. Find the exact maximum value of the function \( f(x) = -3x^2 - 8x - 1 \).

15. Find the equation of the axis of symmetry of the graph of the function \( f(x) = -4x^2 - 2x + 9 \).

16. Find the exact minimum value of the function \( f(x) = 5x^2 + 2x - 3 \).

17. A ball is thrown upward at a speed of 8 ft/s from the top of a 182 foot high building. How many seconds does it take for the ball to reach its maximum height? Round your answer to the nearest hundredth of a second.

18. A ball is thrown upward at a speed of 9 ft/s from the top of a 143 foot high building. How many seconds does it take for the ball to reach its maximum height? Round your answer to the nearest hundredth of a second.

19. A ball is thrown upward at a speed of 52 ft/s from the top of a 293 foot high building. What is the maximum height of the ball? Round your answer to the nearest hundredth of a foot.

20. A ball is thrown upward at a speed of 23 ft/s from the top of a 71 foot high building. What is the maximum height of the ball? Round your answer to the nearest hundredth of a foot.

21. Find two numbers whose sum is 20 and whose product is a maximum.

22. Find two numbers whose sum is 36 and whose product is a maximum.

23. Find two numbers whose difference is 12 and whose product is a minimum.
24. Find two numbers whose difference is 24 and whose product is a minimum.

25. One number is 3 larger than twice a second number. Find two such numbers so that their product is a minimum.

26. One number is 2 larger than 5 times a second number. Find two such numbers so that their product is a minimum.

27. Among all pairs of numbers whose sum is −10, find the pair such that the sum of their squares is the smallest possible.

28. Among all pairs of numbers whose sum is −24, find the pair such that the sum of their squares is the smallest possible.

29. Among all pairs of numbers whose sum is 14, find the pair such that the sum of their squares is the smallest possible.

30. Among all pairs of numbers whose sum is 12, find the pair such that the sum of their squares is the smallest possible.

31. Among all rectangles having perimeter 40 feet, find the dimensions (length and width) of the one with the greatest area.

32. Among all rectangles having perimeter 100 feet, find the dimensions (length and width) of the one with the greatest area.

33. A farmer with 1700 meters of fencing wants to enclose a rectangular plot that borders on a river. If no fence is required along the river, and the side parallel to the river is x meters long, find the value of x which will give the largest area of the rectangle.

35. A park ranger with 400 meters of fencing wants to enclose a rectangular plot that borders on a river. If no fence is required along the river, and the side parallel to the river is x meters long, find the value of x which will give the largest area of the rectangle.

36. A rancher with 1000 meters of fencing wants to enclose a rectangular plot that borders on a river. If no fence is required along the river, what is the largest area that can be enclosed?

37. Let \( x \) represent the demand (the number the public will buy) for an object and let \( p \) represent the object’s unit price (in dollars). Suppose that the unit price and the demand are linearly related by the equation \( p = (-1/3)x + 40 \).

a) Express the revenue \( R \) (the amount earned by selling the objects) as a function of the demand \( x \).

b) Find the demand that will maximize the revenue.

c) Find the unit price that will maximize the revenue.

d) What is the maximum revenue?

38. Let \( x \) represent the demand (the number the public will buy) for an object and let \( p \) represent the object’s unit price (in dollars). Suppose that the unit price and the demand are linearly related by the equation \( p = (-1/5)x + 200 \).

a) Express the revenue \( R \) (the amount
earned by selling the objects) as a function of the demand $x$.

b) Find the demand that will maximize the revenue.

c) Find the unit price that will maximize the revenue.

d) What is the maximum revenue?

39. A point from the first quadrant is selected on the line $y = mx + b$. Lines are drawn from this point parallel to the axes to form a rectangle under the line in the first quadrant. Among all such rectangles, find the dimensions of the rectangle with maximum area. What is the maximum area? Assume $m < 0$.

40. A rancher wishes to fence a rectangular area. The east-west sides of the rectangle will require stronger support due to prevailing east-west storm winds. Consequently, the cost of fencing for the east-west sides of the rectangular area is $18$ per foot. The cost for fencing the north-south sides of the rectangular area is $12$ per foot. Find the dimension of the largest possible rectangular area that can be fenced for $7200$. 
5.6 Answers

1. \( \frac{9}{4} \)

3. \( \left( -\frac{1}{6}, -\frac{71}{12} \right) \)

5. \( \frac{11}{4} \)

7. \( \left( -\frac{1}{2}, -\frac{33}{4} \right) \)

9. \( -\frac{81}{4} \)

11. \( (-\infty, \frac{10}{3}] = \left\{ x \mid x \leq \frac{10}{3} \right\} \)

13. \( \left[ -\frac{209}{16}, \infty \right) = \left\{ x \mid x \geq -\frac{209}{16} \right\} \)

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

17. \( 0.25 \)

19. \( 335.25 \)

21. \( 10 \text{ and } 10 \)

23. \( 6 \text{ and } -6 \)

25. \( 3/2 \text{ and } -3/4 \)

27. \( -5, -5 \)

29. \( 7, 7 \)

31. \( 10 \text{ feet by } 10 \text{ feet} \)

33. \( 361250 \text{ square meters} \)

35. \( 200 \)

37. a) \( R = (-1/3)x^2 + 40x \)

b) \( x = 60 \text{ objects} \)

c) \( p = 20 \text{ dollars} \)

d) \( R = $1200 \)

39. \( x = -b/(2m), y = b/2, A = -b^2/(4m) \)