

Chapter 9

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**Chapter
9**

Solving Quadratic Equations

Dear Family,

In the last chapter, your student looked at the graphs of quadratic equations. These graphs are in the shape of a U and known as parabolas. In this chapter, your student will continue his or her study of quadratic equations. A common use of quadratic equations is projectile motion. Your student has already used the equation $s(t) = -gt^2 + v_0t + h_0$, where g is the value of the force of gravity (16 when working with feet), v_0 is the initial velocity, h_0 is the initial height, and t is time.

Can you think of some examples of projectile motion besides tossing a ball? List as many as you can.

One application of projectile motion is the path of an object shot out of a cannon.

- Research the history of cannons.
- In a paragraph or two, write a summary of how cannons were used in battle.
- What were some of the benefits of using cannons in battle? What were some of the drawbacks?
- Besides ammunition, are cannons used to launch anything else?

Consider the catapult.

- What is a catapult? Research what a catapult looks like and how it works.
- How is a catapult different from a cannon? How is it the same?

After researching how a catapult works, try to construct your own catapult using household items. Then test your catapult by launching an item, such as a ball or marshmallow.

- What do you notice about the path of the item being launched? Would a cannon send the object in a similar path?
- Does the shape of the path look familiar?
- From your research, would you rather go to battle with a cannon or a catapult? Explain your reasoning.

Happy launching!

**Capítulo
9**

Resolver ecuaciones cuadráticas

Estimada familia:

En el capítulo anterior, su hijo observó las gráficas de ecuaciones cuadráticas. Estas gráficas tienen forma de U y se conocen como paráboles. En este capítulo, su hijo continuará estudiando ecuaciones cuadráticas. Un uso común de las ecuaciones cuadráticas para describir el movimiento de un proyectil. Su hijo ya ha usado la ecuación $s(t) = -gt^2 + v_0t + h_0$, donde g es el valor de la fuerza de gravedad (16 cuando se trabaja con los pies), v_0 es la velocidad inicial, h_0 es la altura inicial y t es el tiempo.

¿Se les ocurren algunos ejemplos de movimiento de proyectil además de lanzar una pelota? Enumeren todos los que puedan.

Un uso para el movimiento de proyectil es la trayectoria de un objeto que se dispara desde un cañón.

- Investiguen sobre la historia de los cañones.
- En uno o dos párrafos, escriban un resumen de cómo se usan los cañones en una batalla.
- ¿Cuáles son algunos de los beneficios de usar cañones en una batalla?
¿Cuáles son algunas de las desventajas?
- Además de la munición, ¿los cañones se usan para lanzar alguna otra cosa?

Consideren la catapulta.

- ¿Qué es una catapulta? Investiguen cómo luce una catapulta y cómo funciona.
- ¿En qué se diferencia una catapulta de un cañón? ¿En qué se parece?

Después de investigar cómo funciona una catapulta, traten de construir su propia catapulta usando objetos de la casa. Luego, para probar la catapulta, lancen un objeto, tal como una pelota o un malvavisco.

- ¿Qué observan sobre la trayectoria del objeto lanzado? ¿Un cañón enviaría al objeto por una trayectoria similar?
- ¿La forma de la trayectoria les parece familiar?
- Basándose en su investigación, ¿preferirían pelear una batalla con un cañón o una catapulta? Expliquen su razonamiento.

¡Feliz lanzamiento!

9.1 Start Thinking

Simplify $\sqrt{360}$ using the steps below.

Step 1 Make a list of factors of 360.

Step 2 Find the greatest perfect square factor.

Step 3 Rewrite the radical as the product of the perfect square factor and its pair.

Step 4 Separate the product as two radicals.

Step 5 Simplify the square root radical.

Step 6 Write the answer as the product of a whole number and a radical.

9.1 Warm Up

Simplify.

1. $\sqrt{16}$

2. $\sqrt{64}$

3. $\sqrt{225}$

4. $\sqrt{2025}$

5. $\sqrt{57,600}$

6. $\sqrt{36}$

7. $\sqrt{400}$

8. $\sqrt{4}$

9. $\sqrt{3600}$

9.1 Cumulative Review Warm Up

Determine whether the function represents **exponential growth** or **exponential decay**. Identify the percent rate of change.

1. $y = 5(0.7)^t$

2. $y = 49(1.04)^t$

3. $r(t) = 0.5(0.95)^t$

4. $g(t) = 3\left(\frac{4}{5}\right)^t$

9.1 Practice A

In Exercises 1–9, simplify the expression.

1. $\sqrt{50}$

2. $\sqrt{68}$

3. $-\sqrt{98}$

4. $\sqrt{\frac{9}{25}}$

5. $-\sqrt{\frac{3}{64}}$

6. $-\sqrt{\frac{x^2}{4}}$

7. $\sqrt[3]{24}$

8. $\sqrt[3]{-250}$

9. $-\sqrt[3]{128x^4}$

10. Describe and correct the error in simplifying the expression.

$\times \quad \sqrt[3]{16} = 4$

In Exercises 11–13, write a factor that you can use to rationalize the denominator of the expression.

11. $\frac{3}{\sqrt{5}}$

12. $\frac{1}{\sqrt{7n}}$

13. $\frac{5}{\sqrt[3]{9}}$

In Exercises 14–22, simplify the expression.

14. $\frac{3}{\sqrt{3}}$

15. $\frac{9}{\sqrt{5}}$

16. $\frac{\sqrt{3}}{\sqrt{50}}$

17. $\frac{4}{\sqrt{w}}$

18. $\frac{1}{\sqrt{5t}}$

19. $\sqrt{\frac{2z^2}{7}}$

20. $\frac{1}{\sqrt{6} - 1}$

21. $\frac{3}{4 + \sqrt{2}}$

22. $\frac{\sqrt{3}}{5 - \sqrt{2}}$

23. The average annual interest rate r (in decimal form) of a savings account is represented by the formula $r = \sqrt{\frac{V_2}{V_0}} - 1$, where V_0 is the initial investment and V_2 is the balance of the account after 2 years. Find the average annual interest rate r of a savings account with an initial investment of \$400 and a balance of \$422 after 2 years.

9.1 Practice B

In Exercises 1–9, simplify the expression.

1. $\sqrt{54}$

2. $\sqrt{25y^2}$

3. $-\sqrt{18n^3}$

4. $\sqrt{\frac{29}{100}}$

5. $\sqrt{\frac{p^3}{49}}$

6. $\sqrt{\frac{36}{9x^2}}$

7. $\sqrt[3]{32q^2}$

8. $\sqrt[3]{\frac{9d}{-8}}$

9. $-\sqrt[3]{\frac{60x^2}{729y^3}}$

10. Describe and correct the error in simplifying the expression.

$$\times \quad \sqrt{\frac{30}{25}} = \sqrt{\frac{6}{5}}$$

$$= \frac{\sqrt{6}}{\sqrt{5}}$$

In Exercises 11–13, write a factor that you can use to rationalize the denominator of the expression.

11. $\frac{2}{\sqrt{7}y}$

12. $\frac{8}{\sqrt[3]{k^2}}$

13. $\frac{2}{3 - \sqrt{6}}$

In Exercises 14–22, simplify the expression.

14. $\frac{4}{\sqrt{3}}$

15. $\frac{\sqrt{2}}{\sqrt{45}}$

16. $\frac{1}{\sqrt{6t}}$

17. $\sqrt{\frac{5h^2}{7}}$

18. $\frac{\sqrt{27}}{\sqrt{2d^3}}$

19. $\frac{25}{\sqrt[3]{4}}$

20. $\frac{5}{7 - \sqrt{2}}$

21. $\frac{\sqrt{3}}{8 + \sqrt{7}}$

22. $\frac{\sqrt{5}}{\sqrt{5} - \sqrt{7}}$

23. Use the special product pattern $(a - b)(a^2 + ab + b^2) = a^3 - b^3$ to simplify the expression $\frac{3}{\sqrt[3]{x} - 1}$.

9.1 Enrichment and Extension

Simplify Radicals With Imaginary Numbers

Think about the equation $x^2 = -1$ and notice that there is nothing that can make the equation true while using real numbers. It is not possible to substitute any real number for x that will yield a solution of -1 . This is where imaginary numbers come in. Use the definition $i = \sqrt{-1}$ when simplifying radicals of negative numbers.

Example: Simplify $\sqrt{-120x^2y^3}$.

$$\sqrt{-120x^2y^3} = \sqrt{-1 \bullet 4 \bullet 30 \bullet x^2 \bullet y^2 \bullet y} = 2ixy\sqrt{30y}$$

Simplify the expression using the definition $i = \sqrt{-1}$.

1. $\sqrt{-80}$

2. $\sqrt{-50xy^2}$

3. $\sqrt{-216}$

4. $\sqrt{-32w^2z^4}$

5. $\sqrt{-175pqr^6}$

6. $\sqrt{-22x^3}$

7. $\frac{\sqrt{-15}}{\sqrt{3}}$

8. $\frac{2\sqrt{-21}}{\sqrt{7}}$

9. $\frac{\sqrt{-2}}{\sqrt{5}}$

10. $\sqrt{-8} \bullet \sqrt{5}$

11. $\sqrt{3} \bullet \sqrt{-27}$

12. $\sqrt{-2xy} \bullet \sqrt{30x^2y}$

13. $\frac{-3\sqrt{-20}}{2\sqrt{8}}$

14. $\frac{3}{\sqrt{-2}}$

15. $\frac{-\sqrt{-12xy^3}}{\sqrt{6x^3y}}$



9.1 Puzzle Time

What Do You Say When You Get Off A Boat?

Write the letter of each answer in the box containing the exercise number.

Simplify the expression.

1. $\sqrt{28}$

2. $-\sqrt{75}$

3. $\sqrt{63x^3}$

4. $-\sqrt{\frac{36x^2}{121}}$

5. $\sqrt{\frac{x^5}{64}}$

6. $\sqrt[3]{-54}$

7. $-\sqrt[3]{\frac{125x^2}{343y^3}}$

8. $\sqrt[3]{\frac{729}{-1000x^3y^6}}$

9. $\frac{6}{\sqrt{11}}$

10. $\sqrt{\frac{8}{28}}$

11. $\frac{\sqrt{12}}{\sqrt{5x^3}}$

12. $\frac{2}{\sqrt{13} + 1}$

13. $\frac{\sqrt{7}}{9 + \sqrt{7}}$

14. $\sqrt{2} - 3\sqrt{17} + 7\sqrt{2}$

15. $8\sqrt{24} - 6\sqrt{54}$

16. $(\sqrt{10} + \sqrt{40})(\sqrt{50} - \sqrt{18})$

17. The length of the board for a shelf is $(\sqrt{27} + \sqrt{3})$ feet.

The width of the board is $2\sqrt{2}$ feet. Find the area of the board.

Answers

U. $-\frac{5\sqrt[3]{x^2}}{7y}$

R. $3x\sqrt{7x}$

N. $\frac{x^2\sqrt{x}}{8}$

M. $-\frac{9}{10xy^2}$

T. $8\sqrt{6}$

Y. $\frac{6\sqrt{11}}{11}$

C. $\frac{-1 + \sqrt{13}}{6}$

H. $-2\sqrt{6}$

O. $-5\sqrt{3}$

E. $2\sqrt{7}$

H. $12\sqrt{5}$

A. $\frac{-7 + 9\sqrt{7}}{74}$

F. $8\sqrt{2} - 3\sqrt{17}$

R. $-3\sqrt[3]{2}$

K. $\frac{\sqrt{14}}{7}$

Y. $\frac{2\sqrt{15x}}{5x^2}$

U. $\frac{6x}{11}$

17	15	13	5	10		11	2	7		14	1	6	3	9		8	4	12	16
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9.2 Start Thinking

Use a graphing calculator to graph the function $y = x^2 - 2x - 3$. How many times does the parabola cross the x -axis? Name the point(s) where the graph crosses the x -axis.

Use the CALC feature on the graphing calculator to find the zeros of the function. How does this relate to the points you found? Explain why these points are called zeros.

9.2 Warm Up

Solve.

1. $9x - 4 = 5x - 12$

2. $14b = 5b + 18$

3. $4x = 12 + x$

4. $5y + 1 = -14 + 2y$

5. $5y + 7 = 2y + 7$

6. $10 + 3n = 15 - 2n$

9.2 Cumulative Review Warm Up

Solve the equation.

1. $x(x - 9) = 0$

2. $11t(2t + 4) = 0$

3. $(s + 10)s = 0$

4. $(3a + 6)(4a - 16) = 0$

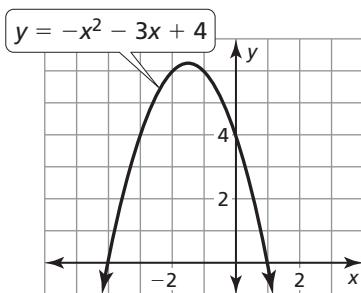
5. $(6m - 3)^2 = 0$

6. $(4 + g)(8 - 2g) = 0$

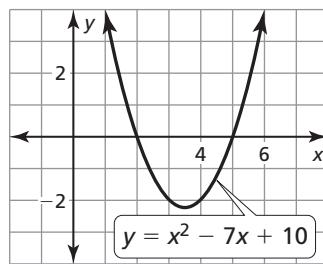
9.2 Practice A

In Exercises 1 and 2, use the graph to solve the equation.

1. $-x^2 - 3x + 4 = 0$



2. $x^2 - 7x + 10 = 0$



In Exercises 3–5, write the equation in standard form.

3. $3x^2 = 15$

4. $-x^2 = -14$

5. $4x - 2x^2 = 5$

In Exercises 6–11, solve the equation by graphing.

6. $x^2 + 3x = 0$

7. $x^2 + 2x + 1 = 0$

8. $x^2 - 3x + 6 = 0$

9. $x^2 - 4x - 5 = 0$

10. $-x^2 = 7x + 18$

11. $x^2 = -2x + 3$

12. The height y (in feet) of a toss in bocce ball can be modeled by $y = -x^2 + 4x$, where x is the horizontal distance (in feet).

a. Interpret the x -intercepts of the graph of the equation.

b. How far away does the bocce ball land on the ground?

In Exercises 13–15, solve the equation by using Method 2 from Example 3.

13. $x^2 = 4x + 12$

14. $8x - 15 = x^2$

15. $x^2 + 9x = 10$

In Exercises 16–19, graph the function. Approximate the zeros of the function to the nearest tenth when necessary.

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

17. $f(x) = -x^2 + 8x - 6$

18. $y = \frac{1}{3}x^2 + 2x - 4$

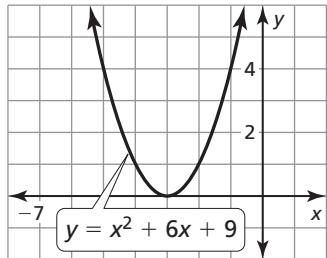
19. $y = -2x^2 + 3x - 2$

20. The area (in square feet) of an x -foot-wide sidewalk can be modeled by $y = -0.002x^2 + 0.006x$. Find the width of the sidewalk to the nearest foot.

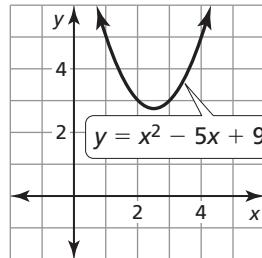
9.2 Practice B

In Exercises 1 and 2, use the graph to solve the equation.

1. $x^2 + 6x + 9 = 0$



2. $x^2 - 5x + 9 = 0$



In Exercises 3–5, write the equation in standard form.

3. $-x^2 = 23$

4. $3 - 5x^2 = 9x$

5. $6 - 2x = 7x^2$

In Exercises 6–11, solve the equation by graphing.

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

7. $x^2 - 12x + 36 = 0$

8. $x^2 - 4x + 8 = 0$

9. $6x - 7 = -x^2$

10. $x^2 = -x - 1$

11. $9 - x^2 = -8x$

12. The height h (in feet) of a fly ball in a baseball game can be modeled by $h = -16t^2 + 28t + 8$, where t is the time (in seconds).

- Do both t -intercepts of the graph of the function have meaning in this situation? Explain.
- No one caught the fly ball. After how many seconds did the ball hit the ground?

In Exercises 13–15, solve the equation by using Method 2 from Example 3.

13. $x^2 = 6x + 7$

14. $-20 = x^2 + 9x$

15. $x^2 - 24 = 10x$

In Exercises 16–19, graph the function. Approximate the zeros of the function to the nearest tenth when necessary.

16. $f(x) = x^2 + 5x + 2$

17. $f(x) = x^2 - 4x + 3$

18. $y = -x^2 + 3x - 5$

19. $y = \frac{1}{2}x^2 - 3x + 1$

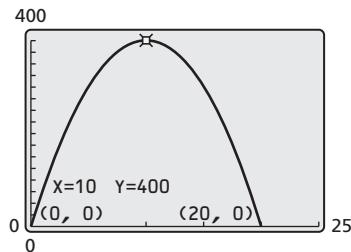
20. The area (in square feet) of an x -foot-wide path can be modeled by $y = -0.002x^2 + 0.006x$. Find the width of the path to the nearest foot.

9.2 Enrichment and Extension

Graphical Representations of Quadratic Word Problems

To solve real-life quadratic word problems, you can use a graphing calculator to interpret data and yield solutions to the problems at hand. By using the *calculate* function on the calculator, you can find maximum and minimum values as well as zeros of the function. You can also use the table feature to find other values needed.

$$f(t) = -4t^2 + 80t$$



Solve the exercise by analyzing the graph of the equation and using the features of your graphing calculator.

1. The height h (in feet) of a rocket above the ground after t seconds of motion is given by the formula $h(t) = -16t^2 + 100t$.
 - a. How long does it take the rocket to reach a height of 144 feet? Round your answer to the nearest hundredth of a second.
 - b. How long does it take the rocket to hit the ground? Round your answer to the nearest hundredth of a second.
2. The opening of a tunnel underneath a mountain can be modeled by the function $h(f) = -\frac{1}{30}f^2 + 2f$, where h is the height of the tunnel (in feet) and f is the distance (in feet) from the bottom of the left edge of the tunnel opening. What is the width across the bottom of the tunnel?
3. The function $I(t) = -0.2t^2 + 3.4t$ represents the yearly income or loss I (in dollars) from a real estate investment, where t is time in years after 1990. During what year did the investor earn the maximum amount of income?
4. The equation for cost C (in dollars) of producing each individual automobile tire in a vehicle factory is $C(x) = 0.00003x^2 - 0.06x + 65$, where x represents the number of tires produced.
 - a. Find the number of tires the factory should make to minimize the cost of each individual tire.
 - b. What would be the cost of each tire?



9.2 Puzzle Time

Why Do They Call The New Dance The Elevator?

Write the letter of each answer in the box containing the exercise number.

Write the equation in standard form.

1. $5x^2 = 14$

2. $-3x^2 = 16$

3. $7x - 8x^2 = 6$

4. $9 + 10x = 12x^2$

Solve the equation by graphing.

5. $x^2 - 6x = 0$

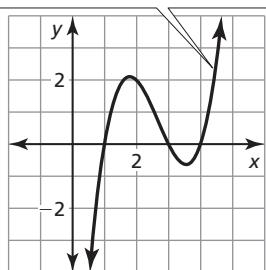
6. $x^2 - 3x + 7 = 0$

7. $x^2 = -8x - 16$

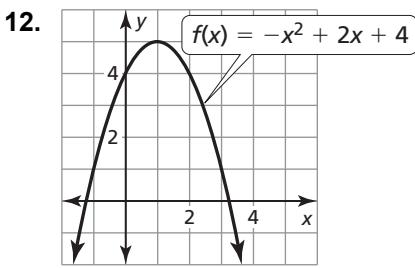
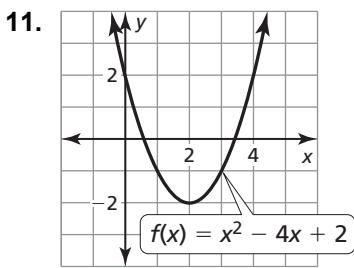
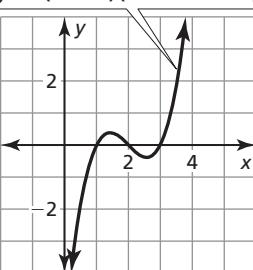
8. $-x^2 = -10x + 24$

Find the zero(s) of f . Approximate the zero(s) of f to the nearest tenth when necessary.

9. $y = (x - 1)(x^2 - 7x + 12)$



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



Answers

S. $3x^2 + 16 = 0$

T. $12x^2 - 10x - 9 = 0$

N. $8x^2 - 7x + 6 = 0$

A. $5x^2 - 14 = 0$

E. 4, 6

S. no solution

H. 0.6, 3.4

T. 0, 6

P. 1, 2, 3

I. -4

O. 1, 3, 4

S. -1.2, 3.2

7	4		11	1	6		3	9		12	5	8	10	2
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9.3 Start Thinking

Use a graphing calculator to complete the table.

Function	Number of zeros
$f(x) = x^2 - 4$	
$f(x) = x^2 - 9$	
$f(x) = x^2$	
$f(x) = -x^2$	
$f(x) = x^2 + 4$	
$f(x) = x^2 + 9$	

In each function in the table, replace $f(x)$ with zero and move the constant to the opposite side of the equation. Describe the pattern between the sign of the constant in the equations and the number of zeros in the function.

9.3 Warm Up

Solve.

1. $2x - 2 = 8$
2. $7 = 3x - 11$
3. $2 + 4w = -6$
4. $8a + 19 = 3$

9.3 Cumulative Review Warm Up

Determine whether the function is **even, odd, or neither**.

1. $y = x^2 - 3$
2. $f(x) = -4x^2 - 11x - 4$
3. $f(x) = -2x^2 - 3x - 1$
4. $y = -3x$

9.3 Practice A

In Exercises 1–3, determine the number of real solutions of the equation. Then solve the equation using square roots.

1. $x^2 = 36$

2. $x^2 = -16$

3. $x^2 = 0$

In Exercises 4–12, solve the equation using square roots.

4. $x^2 - 9 = 0$

5. $x^2 + 8 = 0$

6. $2x^2 + 10 = 0$

7. $x^2 - 24 = 40$

8. $2x^2 - 72 = 0$

9. $-x^2 + 25 = 25$

10. $(x - 4)^2 = 0$

11. $(x + 2)^2 = 9$

12. $(3x + 1)^2 = 49$

In Exercises 13–15, solve the equation using square roots. Round your solutions to the nearest hundredth.

13. $x^2 + 5 = 11$

14. $x^2 - 8 = 10$

15. $3x^2 - 1 = 14$

16. Describe and correct the error in solving the equation $x^2 - 9 = 16$ using square roots.

$$\times \quad x^2 - 9 = 16$$

$$x - 3 = 4$$

$$x = 7$$

17. A rectangular box has a height of 7 centimeters and a volume of 336 cubic centimeters. The length of the box is three times the width.
- Write an equation describing this situation.
 - Find the length and width of the box.
18. Without graphing, where do the graphs of $y = x^2$ and $y = 25$ intersect? Explain.
19. Without graphing, where do the graphs of $y = x^2$ and $y = 1.21$ intersect? Explain.

9.3 Practice B

In Exercises 1–3, determine the number of real solutions of the equation. Then solve the equation using square roots.

1. $x^2 = 121$

2. $x^2 = -15$

3. $x^2 = 196$

In Exercises 4–12, solve the equation using square roots.

4. $x^2 + 9 = 0$

5. $4x^2 - 16 = 0$

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

7. $5x^2 - 21 = 24$

8. $9x^2 + 7 = 8$

9. $4x^2 - 38 = 43$

10. $(x + 5)^2 = 49$

11. $(4x - 3)^2 = 25$

12. $25(x - 1)^2 = 49$

In Exercises 13–15, solve the equation using square roots. Round your solutions to the nearest hundredth.

13. $2x^2 + 7 = 21$

14. $-16 = 8 - 3x^2$

15. $5 = 9x^2 - 6$

16. Describe and correct the error in solving the equation $x^2 + 25 = 9$ using square roots.

$$\begin{array}{l} \times \quad x^2 + 25 = 9 \\ \quad \quad x^2 = -16 \\ \quad \quad x = \pm 4 \end{array}$$

17. A can of juice has a height of 10 inches and a volume of 160π cubic inches. The volume of a can with radius r is given by the formula $V = \pi r^2 h$.
- Write an equation describing this situation, where r is the radius of the can.
 - Find the radius of the can.
18. Solve each equation without graphing.

a. $x^2 + 6x + 9 = 25$

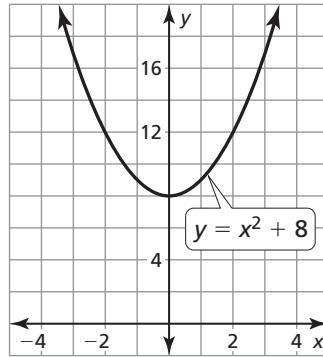
b. $x^2 - 10x + 25 = 49$

c. $x^2 - 1 = 24$

9.3 Enrichment and Extension

Imaginary Solutions

While solving quadratic equations, you have learned how to find roots of real numbers, whether they are rational or irrational roots. You have also been able to estimate the roots using a calculator. These are all considered real number roots. However, what happens when a parabola does not cross the x -axis? Is there still a solution to the problem? The answer is yes. A non-real solution to a quadratic equation is known as an *imaginary* or *complex solution*, and you must use $i = \sqrt{-1}$ to solve the problem.



Example: Solve $y = x^2 + 8$ by taking square roots.

$$0 = x^2 + 8 \quad \text{Set equation to 0.}$$

$$-8 = x^2 \quad \text{Subtract 8 from each side.}$$

$$\pm\sqrt{-8} = \sqrt{x^2} \quad \text{Take square root of each side.}$$

$$\pm 2i\sqrt{2} = x \quad \text{Simplify radical by using } i = \sqrt{-1}.$$

Solve the equation by taking square roots. State whether the roots are *rational*, *irrational*, or *imaginary*.

1. $y = -x^2$
2. $y = x^2 + 1$
3. $y = -x^2 - 5$
4. $y = \frac{1}{2}x^2 - 6$
5. $y = 2x^2 - 3$
6. $y = 3x^2 + 4$
7. $y = 5x^2 + 20$
8. $y = -6x^2 - 15$
9. $y = (x - 2)^2 + 4$



9.3 Puzzle Time

What Did The Chef Say To The Hungry Watch?

Write the letter of each answer in the box containing the exercise number.

Solve the equation using square roots. Round your solutions to the nearest hundredth, if necessary.

1. $x^2 = 49$

2. $x^2 = -121$

3. $x^2 - 64 = 0$

4. $5x^2 - 20 = 0$

5. $x^2 + 8 = 15$

6. $-4x^2 - 9 = -9$

7. $16x^2 + 3 = 4$

8. $7x^2 - 10 = 11$

9. $(x + 4)^2 = 0$

10. $(x - 2)^2 = 25$

11. $(5x + 1)^2 = 196$

12. $9(x + 3)^2 = 36$

13. $6x^2 - 15 = 21$

14. $25(x - 8)^2 = 81$

15. You drop a feather from a height of 160 centimeters. The function $h = -16x^2 + 160$ represents the height h (in centimeters) of the feather after x seconds. How long does it take the feather to touch the ground?

Answers

C. -4

W. no real solution

S. $-3, \frac{13}{5}$

E. -2.65, 2.65

A. $-\frac{1}{4}, \frac{1}{4}$

B. -2.45, 2.45

N. -8, 8

O. $\frac{31}{5}, \frac{49}{5}$

S. -2, 2

O. 3.16

U. -1.73, 1.73

D. -5, -1

O. -7, 7

H. 0

T. -3, 7

6	14	2		7	13	1	8	10		11	5	9	15	3	12	4
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9.4 Start Thinking

Use a graphing calculator to graph $f(x) = x^2 + 4x - 1$.

Find the minimum of the function using the CALC feature on the graphing calculator. Explain the relationship between the minimum of the function and its vertex.

Graph $g(x) = -x^2 + 2x - 3$. Use the CALC feature to find the maximum of the function. Explain how to know when a quadratic function has a minimum or a maximum.

9.4 Warm Up

Factor.

1. $x^2 - 9$

2. $y^2 + 2y + 1$

3. $4x^2 - 1$

4. $x^2 - 8x + 16$

5. $4a^2 + 4a + 1$

6. $1 - 49x^2$

7. $9a^2 + 6a + 1$

8. $4a^2 - 20a + 25$

9.4 Cumulative Review Warm Up

Solve the equation. Check your solution.

1. $5(z - 4) = 35$

2. $3 - 6m = 27$

3. $26 = 4c + 2(7 + c)$

4. $-3 = 11y + 6(y + 8)$

5. $-3(5g + 2) = 39$

6. $-4h - 3(10 + 2h) = -10$

7. $3n - 12 = 78$

8. $n + 1 = -18$

9.4 Practice A

In Exercises 1–3, find the value of c that completes the square.

1. $x^2 - 6x + c$

2. $x^2 - 10x + c$

3. $x^2 + 2x + c$

In Exercises 4–6, complete the square for the expression. Then factor the trinomial.

4. $x^2 - 4x$

5. $x^2 - 20x$

6. $x^2 + 26x$

In Exercises 7–9, solve the equation by completing the square. Round your answers to the nearest hundredth, if necessary.

7. $x^2 + 8x = 6$

8. $x^2 - 12x = -11$

9. $x^2 + 18x = 7$

10. A rectangular kitchen has an area of 160 square feet. The length is 12 feet more than the width.

- a. Write an equation that represents the area of the kitchen.
- b. Find the dimensions of the kitchen by completing the square.

In Exercises 11–16, solve the equation by completing the square. Round your answers to the nearest hundredth, if necessary.

11. $x^2 - 6x + 18 = 0$

12. $x^2 + 2x - 15 = 0$

13. $2x^2 - 16x + 20 = 0$

14. $3x^2 + 24x + 21 = 0$

15. $-4x^2 - 16x + 19 = -17$

16. $-2x^2 + 12x + 16 = 22$

17. You are completing the square to solve $5x^2 + 30x = 45$. What is the first step?

In Exercises 18–21, determine whether the quadratic function has a maximum or minimum value. Then find the value.

18. $y = x^2 - 6x - 4$

19. $y = x^2 + 8x + 10$

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

21. $y = 2x^2 + 12x - 22$

22. The product of two consecutive even integers that are negative is 224.

- a. Write an equation to find the integers.
- b. Find the two integers.

9.4 Practice B

In Exercises 1–3, find the value of c that completes the square.

1. $x^2 - 16x + c$

2. $x^2 - x + c$

3. $x^2 + 7x + c$

In Exercises 4–6, complete the square for the expression. Then factor the trinomial.

4. $x^2 - 14x$

5. $x^2 + 30x$

6. $x^2 - 9x$

In Exercises 7–9, solve the equation by completing the square. Round your answers to the nearest hundredth, if necessary.

7. $x^2 + 10x = 16$

8. $x^2 - 3x = 7$

9. $x^2 + 15x = 12$

10. A wading pool is 1 foot deep and has a volume of 108 cubic feet. The width is 12 feet less than the length.

- a. Write an equation that represents the volume of the wading pool.
- b. Find the dimensions of the wading pool by completing the square.

In Exercises 11–16, solve the equation by completing the square. Round your answers to the nearest hundredth, if necessary.

11. $x^2 - 10x + 17 = 0$

12. $x^2 + 22x + 25 = 0$

13. $3x^2 - 15x + 27 = 0$

14. $2x^2 + 40x + 32 = 0$

15. $-3x^2 - 12x - 10 = -37$

16. $5x^2 - 15x - 10 = 20$

17. Find all values of b for which $x^2 + bx + 49$ is a perfect square.

In Exercises 18–21, determine whether the quadratic function has a maximum or minimum value. Then find the value.

18. $y = x^2 - 6x + 4$

19. $y = 2x^2 + 16x - 7$

20. $y = -3x^2 - 15x - 21$

21. $y = 5x^2 - 20x + 25$

22. The product of two consecutive odd integers that are positive is 323.

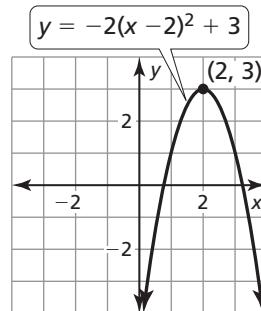
- a. Write an equation to find the integers.
- b. Find the two integers.

9.4 Enrichment and Extension

Vertex Form and Completing the Square

Completing the square is not just used to solve for the roots of an equation. You can also use completing the square to convert standard-form quadratics ($y = ax^2 + bx + c$) into vertex form ($y = a(x - h)^2 + k$).

Example: Convert $y = -2x^2 + 8x - 5$ into vertex form, state the vertex, and graph the equation.



$$\begin{aligned}
 y &= -2x^2 + 8x - 5 \\
 &= -2(x^2 - 4x) - 5 && \text{Factor out } -2 \text{ from the first two terms.} \\
 &= -2(x^2 - 4x + (4)) - 5 - (-8) && \text{Complete the square while subtracting value from end.} \\
 &= -2(x - 2)^2 + 3 && \text{Factor and simplify equation.}
 \end{aligned}$$

Convert the quadratic equation to vertex form, state the vertex, and graph the equation.

1. $y = x^2 - 2x + 6$
2. $y = x^2 + 6x + 1$
3. $y = -x^2 - 2x - 5$
4. $y = 3x^2 - 6x + 2$
5. $y = 2x^2 - 12x + 21$
6. $y = -3x^2 - 12x - 17$
7. $y = 5x^2 + 10x$
8. $y = -\frac{1}{2}x^2 + 4x - 7$
9. $y = \frac{2}{3}x^2 + 4x$



9.4 Puzzle Time

What Does A Magician Need When He Loses His Rabbit?

Write the letter of each answer in the box containing the exercise number.

Complete the square for the expression. Then factor the trinomial.

1. $x^2 - 12x$

2. $x^2 + 18x$

3. $x^2 + 7x$

4. $x^2 - 3x$

Solve the equation by completing the square. Round your solutions to the nearest hundredth, if necessary.

5. $x^2 + 12x = 13$

6. $x^2 - 8x = -7$

7. $x^2 + 6x = 16$

8. $x^2 - 4x - 17 = 0$

9. $3x^2 + 30x + 66 = 0$

10. $-4x^2 - 32x + 80 = 0$

Determine whether the quadratic function has a maximum or minimum value. Then find the value.

11. $y = x^2 - 6x + 4$

12. $y = -x^2 - 14x - 36$

13. A ball is thrown from a height of 5 feet with an initial velocity of 32 feet per second. The height h (in feet) after t seconds is represented by the function $h = -16t^2 + 32t + 5$. Find the maximum height of the ball.

Answers

R. $\left(x + \frac{7}{2}\right)^2$

A. -8, 2

S. $(x - 6)^2$

T. 21

R. 1, 7

E. -2.58, 6.58

O. $\left(x - \frac{3}{2}\right)^2$

R. minimum; (3, -5)

E. -13, 1

H. maximum; (-7, 13)

R. -6.73, -3.27

A. $(x + 9)^2$

E. -10, 2

7		12	2	9	5		11	8	1	13	4	6	10	3
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9.5 Start Thinking

The Quadratic Formula is another way to solve quadratic equations. The Quadratic Formula is $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ for any quadratic equation of the form $ax^2 + bx + c = 0$.

What value(s) of a make the Quadratic Formula undefined? Explain what a function of this form would look like. Are there any other situations that could make the Quadratic Formula undefined? Explain.

9.5 Warm Up

Evaluate.

1. $17 - 14 \div (-2) + (-1)$

2. $-1 - 3[15(4 + 4)]$

3. $97 \bullet 1[13 - (5 + 3)] - 2^3$

4. $17(10 + 1^4) - (-4)$

5. $\frac{(-48) - (-3)}{-7 + 22} \bullet (10 + 3)$

6. $1.2(2.6 + 5.7) - (2.1)^3$

9.5 Cumulative Review Warm Up

Solve the inequality. Graph the solution, if possible.

1. $3|2w - 9| - 11 \geq 4$

2. $-4|3 + 3u| - 6 > -14$

3. $7|-f - 2| - 8 < 6$

4. $\frac{3}{2}|5v - 5| + 3 \geq 9$

5. $|x - 5| < 12$

6. $|n + 6| < 0$

9.5 Practice A

In Exercises 1–3, write the equation in standard form. Then identify the values of a , b , and c that you would use to solve the equation using the Quadratic Formula.

1. $x^2 = -5x$ 2. $x^2 + 3x = -10$ 3. $-5x^2 + 2 = 7x$

In Exercises 4–11, solve the equation using the Quadratic Formula. Round your solutions to the nearest tenth, if necessary.

4. $x^2 + 6x + 9 = 0$	5. $x^2 + 5x + 14 = 0$
6. $x^2 + 9x - 10 = 0$	7. $3x^2 - 2x - 1 = 0$
8. $3x^2 - 5x + 4 = 0$	9. $4x^2 + 4x + 1 = 0$
10. $6x^2 + 5x = 6$	11. $-5x^2 + 9x = -3$

12. Your friend competes in a high-jump competition at a track meet. The function $h = -16t^2 + 18t$ models the height h (in feet) of your friend after t seconds.

- a. After how many seconds is your friend at a height of 4 feet?
- b. After how many seconds does your friend land on the ground?

In Exercises 13–15, determine the number of real solutions of the equation.

13. $x^2 + 2x + 1 = 0$ 14. $x^2 - 4x - 7 = 0$ 15. $3x^2 - 2x = -6$

In Exercises 16–18, find the number of x -intercepts of the graph of the function.

16. $y = -x^2 + 3x + 5$ 17. $y = 3x^2 - 7x + 8$ 18. $y = 5x^2 - 10x + 1$

In Exercise 19–24, solve the equation using any method. Explain your choice of method.

19. $3x^2 = 12$ 20. $3x^2 - 7x + 8 = 0$

21. $x^2 + 8x = 3$ 22. $x^2 = 8 - x$

23. $x^2 - 14x + 49 = 0$ 24. $4x^2 = 20x$

25. Consider the equation $3x^2 + 5x + 6 = 0$.

- a. Use the discriminant to determine the number of solutions.
- b. Change the sign of b in the equation. Write the new equation.
- c. Use the discriminant to determine the number of solutions of the new equation.
Did your answer change? Explain.

9.5 Practice B

In Exercises 1–3, write the equation in standard form. Then identify the values of a , b , and c that you would use to solve the equation using the Quadratic Formula.

1. $x^2 + 2x = 9$

2. $6x - 1 = 7x^2$

3. $-10x + 2 = -4x^2 + 9$

In Exercises 4–11, solve the equation using the Quadratic Formula. Round your solutions to the nearest tenth, if necessary.

4. $x^2 - 8x + 16 = 0$

5. $x^2 + 10x - 11 = 0$

6. $2x^2 - 7x + 3 = 0$

7. $5x^2 + 3x - 1 = 0$

8. $5x^2 - 3x + 4 = 0$

9. $x^2 = -2x - 1$

10. $8x^2 + 9x = 3$

11. $-5x^2 + 2x = 4$

12. You launch a water balloon. The function $h = -0.08t^2 + 1.6t + 2$ models the height h (in feet) of the water balloon after t seconds.

- After how many seconds is the water balloon at a height of 9 feet?
- After how many seconds does the water balloon hit the ground?

In Exercises 13–15, determine the number of real solutions of the equation.

13. $4x^2 = -3x - 8$

14. $-2x^2 - 4x + 7 = 0$

15. $x^2 + 6x + 9 = 0$

In Exercises 16–18, find the number of x -intercepts of the graph of the function.

16. $y = 3x^2 - 6x + 3$

17. $y = 4x^2 + 3x + 9$

18. $y = -2x^2 - 3x + 1$

In Exercise 19–24, solve the equation using any method. Explain your choice of method.

19. $x^2 - 20x = 13$

20. $-7x^2 = 21x$

21. $-9x^2 = 72$

22. $7x^2 + 7 = 8 - 9x$

23. $5x^2 = 4x + 10$

24. $x^2 - 12x + 36 = 0$

25. Consider the equation $3x^2 + 5x + 6 = 0$.

- Use the discriminant to determine the number of solutions.
- Change the sign of c in the equation. Write the new equation.
- Use the discriminant to determine the number of solutions of the new equation. Did your answer change? Explain.

9.5 Enrichment and Extension

Quadratic Functions and Geometry

Area of a rectangle: $A = \ell w$

Area of a triangle: $A = \frac{1}{2}bh$

Pythagorean Theorem: $a^2 + b^2 = c^2$

Area of a Parallelogram: $A = bh$

Solve the quadratic equation using the method of your choice.

1. The hypotenuse of a right triangle is 6 inches longer than the shorter leg. The longer leg is 3 inches longer than the shorter leg. Find the length of the shorter leg.
2. The width of a rectangle is 6 kilometers less than twice its length. If its area is 108 square kilometers, find the dimensions of the rectangle.
3. A picture has a height that is $\frac{4}{3}$ its width. It is to be enlarged to have an area of 192 square inches. What will be the dimensions of the enlargement?
4. The height of a triangle is three times the length of its base. If the area of the triangle is 33 square inches, what are the dimensions of the triangle's base and height?
5. The ratio of the measures of the base and height of a parallelogram is $4:5$. The area of the parallelogram is 800 square centimeters. Find the measure of both the base and height of the parallelogram.



9.5 Puzzle Time

What Do Elephants Take When They Go Away On A Long Trip?

Write the letter of each answer in the box containing the exercise number.

Determine the number of real solutions of the equation.

1. $6x^2 = 6x - 11$
C. One D. Two E. None
2. $-\frac{1}{3}x^2 + 5x = -12$
T. One U. Two V. None

Find the number of x -intercepts of the graph of the function.

3. $y = -x^2 + 7x + 15$
G. One H. Two I. None
4. $y = 3x^2 - 18x + 27$
S. One T. Two U. None

Solve the equation using the Quadratic Formula. Round your solutions to the nearest tenth, if necessary.

5. $x^2 - 9x + 20 = 0$
6. $x^2 + 6x + 5 = 0$
7. $x^2 - 12x + 32 = 0$
8. $3x^2 - 5x + 2 = 0$
9. $1 - 10x = -25x^2$
10. $x^2 + 4x = 7$
11. $8x^2 - 9 = -3x$

Answers

- T. $-5, -1$
- R. $\frac{1}{5}$
- K. $\frac{2}{3}, 1$
- T. 4, 5
- I. 0.9, -1.3
- N. $-5.3, 1.3$
- R. 4, 8

6	3	1	11	7		5	9	2	10	8	4
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9.6 Start Thinking

Use a graphing calculator to graph each system of equations separately.

System 1 $y = x^2 - 10$
 $y = 8$

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

System 3 $y = -4x^2 - 3x$
 $y = 6 + 2x$

Determine which system has two solutions, which has one solution, and which has no solution. Explain.

9.6 Warm Up

Solve using any method.

- | | |
|----------------------------------|------------------------------------|
| 1. $-y = -3x + 6$
$y = -3$ | 2. $5x + 4y = -17$
$y = 2x - 1$ |
| 3. $4x = -7y + 3$
$x = y - 2$ | 4. $6x + 4y = 24$
$y = 5x - 7$ |

9.6 Cumulative Review Warm Up

Graph the linear equation. Identify the x -intercept.

- | | |
|-------------------|-----------------|
| 1. $y = x - 5$ | 2. $y = 3x$ |
| 3. $2x - 2y = -2$ | 4. $y - 3x = 1$ |

9.6 Practice A

In Exercises 1–4, solve the system by graphing.

1. $y = 2x^2 - 3x - 1$

$$y = -x - 1$$

2. $y = x^2 + 4x + 5$

$$y = 2x + 1$$

3. $y = -3x^2 + 6x$

$$y = 3$$

4. $y = -\frac{1}{2}x^2 + 2x - 3$

$$y = -x + 1$$

In Exercises 5–8, solve the system by substitution.

5. $y = x - 4$

$$y = x^2 - 3x - 4$$

6. $y = 8x - 8$

$$y = 2x^2$$

7. $y = x^2 - 5x + 9$

$$y = 3x + 2$$

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

$$y = 3x - 7$$

In Exercises 9–12, solve the system by elimination.

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

$$y = -x + 1$$

10. $y = -4x^2 + 8x - 8$

$$y = -8x + 4$$

11. $y = x^2 + 4x + 5$

$$y = 2x - 4$$

12. $y = 2x^2 + x - 6$

$$y = x + 2$$

In Exercises 13 and 14, use the table to describe the location of the zeros of the quadratic function f .

 13.

x	-4	-3	-2	-1	0	1
$f(x)$	-3	-1	0	0	-1	-3

 14.

x	-1	0	1	2	3	4
$f(x)$	9	7	3	-2	-1	2

15. You shoot an arrow at a target, and your friend throws a javelin at the same target. The height of an arrow can be modeled by $h = -16t^2 + 20t + 14$. The height of the javelin can be modeled by $h = 0.3t + 1$. When will the arrow and the javelin be at the same height?

9.6 Practice B

In Exercises 1–4, solve the system by graphing.

1. $y = 4x^2 + 2x - 1$
 $y = -2x + 7$

2. $y = \frac{1}{3}x^2 - 6x + 5$
 $y = -5x + 5$

3. $y = 4x^2 - 8x$
 $y = -4$

4. $y = 3x^2 - 2x + 8$
 $y = -x$

In Exercises 5–8, solve the system by substitution.

5. $y = 6x$
 $y = x^2 + 9$

6. $y = 2x - 5$
 $y = 2x^2 - 3x + 3$

7. $y = -x^2 - 2x + 4$
 $y = 3x - 10$

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

In Exercises 9–12, solve the system by elimination.

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

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

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

12. $y = -x^2 + 1$
 $y = 2x - 2$

In Exercises 13 and 14, use the table to describe the location of the zeros of the quadratic function f .

 13.

x	-2	-1	0	1	2	3
$f(x)$	-3	-2	-2	0	1	2

 14.

x	-1	0	1	2	3	4
$f(x)$	3	2	-1	2	3	5

15. The graphs of
- $f(x) = 1.6x^2 + 2x - 0.6$
- and
- $g(x) = -2.5x^2 - 2x - 4.2$
- do not intersect. Change the value(s) of
- c
- in one or both functions
- f
- and
- g
- until the two graphs do intersect. Write your new system of equations and determine the intersection point(s), rounding to the nearest hundredth if necessary.

9.6 Enrichment and Extension**Challenge Non-Linear Systems**

Solve using your knowledge of systems of non-linear equations.

1. A science class is studying gravity. The students launch an object up in the air at an initial velocity of 64 feet per second. The object is launched from a height of 6 feet off the ground. Its height H (in feet) after t seconds is given by the equation $H(t) = -16t^2 + v_o t + h_0$.
 - a. At what time is the object 54 feet off the ground?
 - b. How long, to the nearest hundredth of a second, does it take the object to hit the ground?
2. The profit a jacket company makes each day is modeled by the equation $P(x) = -x^2 + 120x - 2000$, where P is the profit and x is the price of each jacket sold. For what value(s) of x does the company make a profit of \$1200?
3. A small electronic company models its annual profits using the function $P(x) = x^2 + 20x - 300$, where P represents the company's profit when x items are sold. Last year, its profits were \$197,625. How many items did the company sell?
4. You and your friends are trying to dunk a basketball. You need to jump at least 2.4 feet above the ground to reach the rim. Your jump is modeled by the function $H(t) = -18t^2 + 14t$.
 - a. Will you jump high enough to dunk the basketball?
 - b. When will you reach 2.4 feet?
5. A diver is jumping from a 12-foot diving board into the school pool. She jumps with an initial upward velocity of 6 feet per second. Use the formula $h(t) = -16t^2 + v_o t + h_o$, where h_o is the initial height, and v_o is the initial upward velocity.
 - a. At what time is the diver 10 feet above the water?
 - b. When will the diver hit the water?



9.6 Puzzle Time

Why Did The Acrobat Join The Circus?

Write the letter of each answer in the box containing the exercise number.

Solve the system by substitution.

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

$$y = x + 3$$

2. $y = x^2 + 6x + 5$

$$y = -3x + 5$$

3. $y = -x^2 + 9x - 4$

$$y = x + 8$$

4. $y = -x^2 + 10$

$$y + 2x = 7$$

5. $y = x^2 - 6x - 2$

$$y = -x - 8$$

6. $y = x^2 + 22x + 17$

$$y = 9x - 25$$

Solve the system by elimination.

7. $y = x^2 + 4x - 24$

$$y = 6x + 11$$

8. $y = -3x^2 + x + 16$

$$y = 7x - 8$$

9. $y = x^2 + 4x - 19$

$$y = -4x + 29$$

10. $y = x^2 + 17x - 27$

$$y = 12x + 23$$

11. $y = 2x^2 - 22x + 1$

$$y = -7x + 9$$

12. $y = x^2 - 2x - 5$

$$y = 6x + 15$$

13. $y = 3x^2 + 6x + 12$

$$y = 2x + 11$$

14. $y = x^2 - 9x - 16$

$$y = -5x + 16$$

Answers

L. $(2, 10), (6, 14)$

V. $(-2, 3), (10, 75)$

O. $(-5, -19), (7, 53)$

L. $(-4, 36), (8, -24)$

E. $(-10, -97), (5, 83)$

T. $(0, 3), (1, 4)$

A. $(-7, -88), (-6, -79)$

B. $(-1, 9), \left(-\frac{1}{3}, \frac{31}{3}\right)$

A. $(-9, 32), (0, 5)$

O. $\left(-\frac{1}{2}, \frac{25}{2}\right), (8, -47)$

T. $(2, -10), (3, -11)$

B. $(-12, 77), (4, 13)$

I. $(-4, -36), (2, 6)$

E. $(-1, 9), (3, 1)$

5	11		9	4		2	13	7	12	10		8	1		6	14	3
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**Chapter
9****Cumulative Review****Solve the equation.**

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

2. $\frac{|6y - 3|}{3} + 5 = 12$

Solve the inequality. Graph the solution, if possible.

3. $|8h + 4| \leq 36$

4. $-2(y - 3) - 5 \geq -3$

5. $-4|3x + 5| + 2 > 10$

6. In one hour, you can earn 350 points in your favorite video game. You already have 1050 points.

a. Write an inequality where y is the total number of points and x is the number of hours.

b. Your goal is 2450 points. What is the least number of hours needed to reach this goal?

7. Four less than two times a number
- x
- is at least 14. Write this sentence as an inequality.

Graph the linear equation or linear inequality.

8. $5x - 7y = 14$

9. $x > 2$

10. $y = 3x - 4$

Write an equation of the line in slope-intercept form that passes through the given point and is perpendicular to the given line.

11. $(-2, 4); y = 2x + 9$

12. $(3, 0); y + 2 = -\frac{1}{4}(x + 9)$

13. $(-8, -12); 18x - 9y = 27$

Solve the system of linear equations by graphing, substitution, or elimination.

14. $y = -2$

15. $5x + 4y = -14$

16. $y = -3x + 7$

$4x - 3y = 18$

$3x + 6y = 6$

$y = -3x - 7$

17. Your school is selling boxes of fruit. Customers can buy small and large boxes of oranges. You sold 3 small and 14 large boxes for a total of \$203. Your friend sold 11 small and 11 large boxes for a total of \$220. Find the cost of one small box and the cost of one large box.

Simplify the expression. Write your answer using only positive exponents.

18. $\frac{25x^{-3}y^{-2}z^{-1}}{100x^6y^{-1}z^0}$

19. $\frac{7m^0}{m^{-3}}$

20. $\frac{x^{-6}y^{-3}z^{-7}}{x^{-5}y^{-4}z^{-8}}$

Solve the equation. Check your solution.

21. $2^{x+7} = 2^8$

22. $4^{7x-14} = 4^{49}$

23. $2^{x-8} = 8^{x+4}$

**Chapter
9****Cumulative Review (continued)****Find the sum or the difference.**

24. $(-7g - 2) + (3g + 15)$

25. $(y - 5) - (-2y - 3)$

Find the product.

26. $(x - 3)(x + 8)$

27. $(-7x - 3y)^2$

Solve the equation.

28. $(3x - 18)(8x + 32) = 0$

29. $25g - 5g^2 = 0$

Factor the polynomial.

30. $m^2 - 6m + 8$

31. $z^2 - 2z - 35$

32. $2w^2 + 6w + 4$

33. An egg is thrown from the top of a tall building. The distance d (in feet) between the egg and the ground t seconds after it is thrown is given by $d = -16t^2 - 80t + 121$. How long after the egg is thrown is it 25 feet from the ground?

Solve the equation.

34. $z^2 - 25 = 0$

35. $y^2 + 22y + 121 = 0$

Factor the polynomial completely.

36. $3x^3 - 15x^2 - 4x + 20$

37. $4y^3 - 4y^2 - 7y + 7$

Graph the function. Compare the graph to the graph of $f(x) = x^2$.

38. $h(x) = 5x^2$

39. $t(x) = 0.375x^2$

40. $n(x) = -\frac{3}{7}x^2$

41. $g(x) = x^2 + 6$

42. $p(x) = 3x^2 + 7$

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

44. The function $f(t) = -16t^2 + s_0$ represents the approximate height (in feet) of an object falling t seconds after it is dropped from an initial height s_0 (in feet). A truck is dropped from a height of 10,000 feet.

- After how many seconds does the truck hit the ground?
- Suppose the initial height is adjusted by k feet. How will this affect part (a)?

Find (a) the axis of symmetry and (b) the vertex of the graph of the function.

45. $y = -5x^2 - 30x - 15$

46. $f(x) = 3x^2 - 30x - 5$

**Chapter
9****Cumulative Review (continued)****Graph the function. Describe the domain and range.**

47. $f(x) = 3x^2 - 6x + 2$

48. $f(x) = -4x^2 + 16x - 1$

Tell whether the function has a minimum value or a maximum value. Then find the value.

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

50. $f(x) = 10x^2 + 60x - 1$

Find the vertex and the axis of symmetry of the graph of the function.

51. $f(x) = \frac{2}{5}(x - 3)^2$

52. $g(x) = 7(x + 5)^2$

53. $g(x) = 3(x - 5)^2 + 4$

Graph the function. Compare the graph to the graph of $f(x) = x^2$.

54. $g(x) = 7(x + 6)^2$

55. $g(x) = \frac{4}{7}(x - 2)^2 - 8$

Graph the quadratic function.

56. $f(x) = 3(x - 2)(x + 6)$

57. $h(x) = x^2 - 3x - 10$

58. Tell whether the data represents a *linear*, an *exponential*, or a *quadratic* function.
Then write the function.

$$(-2, -16), (-1, -15), (0, -12), (1, -7), (2, 0)$$
Simplify the expression.

59. $\sqrt{80y^3}$

60. $\sqrt{\frac{6}{27}}$

61. $-3\sqrt{18} + 3\sqrt{8} - \sqrt{24}$

62. $\sqrt[3]{\frac{64x^5}{250y^9}}$

63. $\sqrt{3}(-5\sqrt{10} + \sqrt{6})$

64. $\frac{2}{2 + \sqrt{4}}$

Solve the equation by graphing.

65. $x^2 + 5x - 36 = 0$

66. $1 = x^2$

67. $x^2 + 4x = 5$

68. $7x - 12 = x^2$

Solve the equation using square roots.

69. $2x^2 = 32$

70. $2x^2 - 40 = 10$

71. $-2x^2 + 2 = 10$

72. A person in a hot air balloon drops a sandwich over the edge from a height of 64 feet. The function $h = -16t^2 + 64$ represents the height h (in feet) of the sandwich after t seconds. How long does it take the sandwich to hit the ground?

**Chapter
9****Cumulative Review (continued)**

Solve the equation by completing the square. Round your solutions to the nearest hundredth, if necessary.

73. $x^2 + 3x + 2 = 0$

74. $y^2 + 12y + 20 = 0$

75. $w^2 + 16w - 22 = 0$

76. $t^2 + 10t + 14 = -7$

77. $7n^2 - 14n - 50 = 6$

78. $3h^2 + 20h + 36 = 4$

79. You want to enclose a rectangular vegetable garden with 60 feet of fence. How should you lay out the fence to maximize area?

Solve the equation using the Quadratic Formula. Round your solutions to the nearest tenth, if necessary.

80. $4x^2 + 8x + 4 = 0$

81. $2y^2 + 3y - 20 = 0$

82. $2w^2 - 7w - 13 = -10$

83. $7z^2 + 4z - 10 = 6$

Find the number of x -intercepts of the graph of the function.

84. $y = x^2 - 2x + 10$

85. $y = x^2 + 4x + 4$

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

87. $y = 2x^2 - 3x + 4$

Solve the system of equations by graphing, elimination, or substitution, if possible.

88. $y = -x^2 + 6$

89. $y = 2x^2 + 3x - 6$

90. $y = 2x^2 - 16x + 35$

$y = -2x - 2$

$y = -x^2$

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

91. A rectangle has an area of 36 square inches and a perimeter of 30 inches. Find the dimensions of the rectangle.