EXAMPLE 5 Model a dropped object with a quadratic function

SCIENCE COMPETITION For a science competition, students must design a container that prevents an egg from breaking when dropped from a height of 50 feet. How long does the container take to hit the ground?

After a successful egg drop

ANOTHER WAY
For alternative methods for solving the problem in Example 5, turn to page 272 for the **Problem Solving Workshop**.

Solution

$h = -16t^2 + h_0$ — Write height function.

$0 = -16t^2 + 50$ — Substitute 0 for h and 50 for h_0.

$-50 = -16t^2$ — Subtract 50 from each side.

$\frac{50}{16} = t^2$ — Divide each side by -16.

$\pm\sqrt{\frac{50}{16}} = t$ — Take square roots of each side.

$\pm 1.8 \approx t$ — Use a calculator.

▶ Reject the negative solution, -1.8, because time must be positive. The container will fall for about 1.8 seconds before it hits the ground.

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GUIDED PRACTICE for Example 5

20. WHAT IF? In Example 5, suppose the egg container is dropped from a height of 30 feet. How long does the container take to hit the ground?

4.5 EXERCISES

HOMEWORK KEY

○ = **WORKED-OUT SOLUTIONS** on p. WS8 for Exs. 17, 27, and 41

★ = **STANDARDIZED TEST PRACTICE** Exs. 2, 19, 34, 35, 36, 40, and 41

SKILL PRACTICE

1. VOCABULARY In the expression $\sqrt{72}$, what is 72 called?

2. ★ WRITING *Explain* what it means to "rationalize the denominator" of a quotient containing square roots.

EXAMPLES 1 and 2 on pp. 266–267 for Exs. 3–20

SIMPLIFYING RADICAL EXPRESSIONS **Simplify the expression.**

3. $\sqrt{28}$ **4.** $\sqrt{192}$ **5.** $\sqrt{150}$ **6.** $\sqrt{3} \cdot \sqrt{27}$

7. $4\sqrt{6} \cdot \sqrt{6}$ **8.** $5\sqrt{24} \cdot 3\sqrt{10}$ **9.** $\sqrt{\frac{5}{16}}$ **10.** $\sqrt{\frac{35}{36}}$

11. $\frac{8}{\sqrt{3}}$ **12.** $\frac{7}{\sqrt{12}}$ **13.** $\sqrt{\frac{18}{11}}$ **14.** $\sqrt{\frac{13}{28}}$

15. $\frac{2}{1-\sqrt{3}}$ **16.** $\frac{1}{5+\sqrt{6}}$ **17.** $\frac{\sqrt{2}}{4+\sqrt{5}}$ **18.** $\frac{3+\sqrt{7}}{2-\sqrt{10}}$

19. ★ **MULTIPLE CHOICE** What is a completely simplified expression for $\sqrt{108}$?

Ⓐ $2\sqrt{27}$ Ⓑ $3\sqrt{12}$ Ⓒ $6\sqrt{3}$ Ⓓ $10\sqrt{8}$

ERROR ANALYSIS *Describe* **and correct the error in simplifying the expression or solving the equation.**

20.

$$\sqrt{96} = \sqrt{4} \cdot \sqrt{24}$$
$$= 2\sqrt{24}$$

21.

$$5x^2 = 405$$
$$x^2 = 81$$
$$x = 9$$

EXAMPLES 3 and 4 on pp. 267–268 for Exs. 21–34

SOLVING QUADRATIC EQUATIONS **Solve the equation.**

22. $s^2 = 169$ **23.** $a^2 = 50$ **24.** $x^2 = 84$

25. $6z^2 = 150$ **26.** $4p^2 = 448$ **27.** $-3w^2 = -213$

28. $7r^2 - 10 = 25$ **29.** $\frac{x^2}{25} - 6 = -2$ **30.** $\frac{t^2}{20} + 8 = 15$

31. $4(x - 1)^2 = 8$ **32.** $7(x - 4)^2 - 18 = 10$ **33.** $2(x + 2)^2 - 5 = 8$

34. ★ **MULTIPLE CHOICE** What are the solutions of $3(x + 2)^2 + 4 = 13$?

Ⓐ $-5, 1$ Ⓑ $-1, 5$ Ⓒ $-2 \pm \sqrt{3}$ Ⓓ $2 \pm \sqrt{3}$

35. ★ **SHORT RESPONSE** *Describe* two different methods for solving the equation $x^2 - 4 = 0$. Include the steps for each method.

36. ★ **OPEN-ENDED MATH** Write an equation of the form $x^2 = s$ that has **(a)** two real solutions, **(b)** exactly one real solution, and **(c)** no real solutions.

37. **CHALLENGE** Solve the equation $a(x + b)^2 = c$ in terms of a, b, and c.

PROBLEM SOLVING

EXAMPLE 5 on p. 269 for Exs. 38–39

38. **CLIFF DIVING** A cliff diver dives off a cliff 40 feet above water. Write an equation giving the diver's height h (in feet) above the water after t seconds. How long is the diver in the air?

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39. **ASTRONOMY** On any planet, the height h (in feet) of a falling object t seconds after it is dropped can be modeled by $h = -\frac{g}{2}t^2 + h_0$ where h_0 is the object's initial height (in feet) and g is the acceleration (in feet per second squared) due to the planet's gravity. For each planet in the table, find the time it takes for a rock dropped from a height of 150 feet to hit the surface.

Planet	Earth	Mars	Jupiter	Saturn	Pluto
g (ft/sec^2)	32	12	76	30	2

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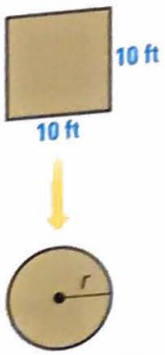
○ = WORKED-OUT SOLUTIONS on p. WS1

★ = STANDARDIZED TEST PRACTICE

40. ★ **SHORT RESPONSE** The equation $h = 0.019s^2$ gives the height h (in feet) of the largest ocean waves when the wind speed is s knots. *Compare* the wind speeds required to generate 5 foot waves and 20 foot waves.

41. ★ **EXTENDED RESPONSE** You want to transform a square gravel parking lot with 10 foot sides into a circular lot. You want the circle to have the same area as the square so that you do not have to buy any additional gravel.



a. **Model** Write an equation you can use to find the radius r of the circular lot.

b. **Solve** What should the radius of the circular lot be?

c. **Generalize** In general, if a square has sides of length s, what is the radius r of a circle with the same area? *Justify* your answer algebraically.

42. **BICYCLING** The air resistance R (in pounds) on a racing cyclist is given by the equation $R = 0.00829s^2$ where s is the bicycle's speed (in miles per hour).

a. What is the speed of a racing cyclist who experiences 5 pounds of air resistance?

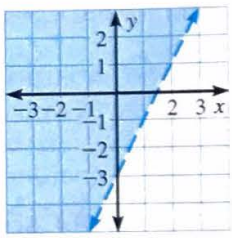
b. What happens to the air resistance if the cyclist's speed doubles? *Justify* your answer algebraically.

43. **CHALLENGE** For a swimming pool with a rectangular base, Torricelli's law implies that the height h of water in the pool t seconds after it begins draining is given by $h = \left(\sqrt{h_0} - \frac{2\pi d^2\sqrt{3}}{lw}t\right)^2$ where l and w are the pool's length and width, d is the diameter of the drain, and h_0 is the water's initial height. (All measurements are in inches.) In terms of l, w, d, and h_0, what is the time required to drain the pool when it is completely filled?

MISSOURI MIXED REVIEW

TEST PRACTICE at classzone.com

44. The graph of which inequality is shown?



Ⓐ $y < 2x - 3$

Ⓑ $y > 2x - 3$

Ⓒ $y \leq 2x - 3$

Ⓓ $y \geq 2x - 3$

45. Which two lines are perpendicular?

Ⓐ $3x + y = -1$ and $x + 3y = -24$

Ⓑ $3x - y = 12$ and $3x + y = 15$

Ⓒ $3x + y = -1$ and $-x + 3y = 6$

Ⓓ $3x - y = 12$ and $x - 3y = 9$