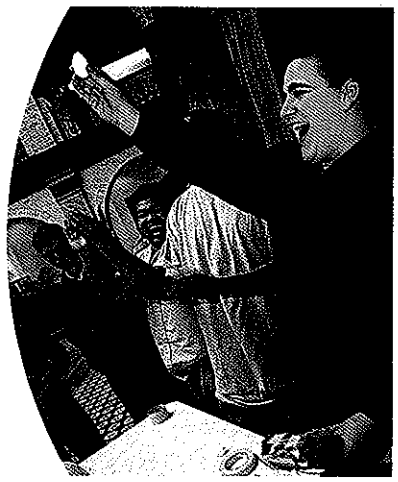
EXAMPLE 5 Model a dropped object with a quadratic function

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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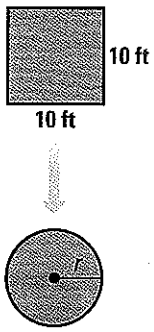
◯ = **WORKED-OUT SOLUTIONS** on p. WS1

★ = **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.

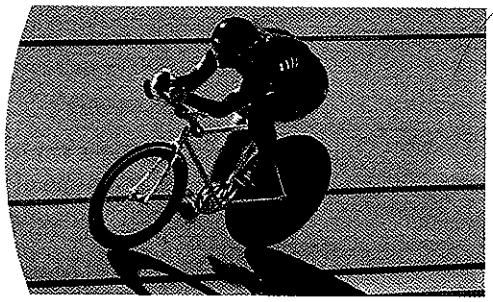


a. Model Write an equation you can use to find the radius r of the circular lot.

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?

MIXED REVIEW

PREVIEW
Prepare for Lesson 4.6 in Exs. 44–51.

Evaluate the power. *(p. 10)*

44. $(-5)^2$ **45.** $(-4)^2$ **46.** $(-8)^2$ **47.** $(-13)^2$

48. -3^2 **49.** -11^2 **50.** -15^2 **51.** -7^2

Solve the equation or inequality.

52. $x - 8 = 2$ *(p. 18)* **53.** $3x + 4 = 13$ *(p. 18)* **54.** $2x - 1 = 6x + 3$ *(p. 18)*

55. $x + 9 > 5$ *(p. 41)* **56.** $-7x - 15 \geq 6$ *(p. 41)* **57.** $3 - 6x \leq 23 - 10x$ *(p. 41)*

58. $|x + 12| = 5$ *(p. 51)* **59.** $|-2 + 3x| = 10$ *(p. 51)* **60.** $\left|\frac{1}{2}x + 9\right| \geq 4$ *(p. 51)*

In Exercises 61 and 62, (a) draw a scatter plot of the data, (b) approximate the best-fitting line, and (c) estimate y when $x = 20$. *(p. 113)*

61.

x	−4	−3	0	2	5
y	5	9	28	33	39

62.

x	1	2	3	4	5
y	120	91	58	31	5