Lesson 8

Roots

Vocabulary Start-Up

A **square root** of a number is one of its two equal factors. Numbers such as 1, 4, 9, 16, and 25 are called **perfect squares** because they are squares of integers.

Complete the graphic organizer.

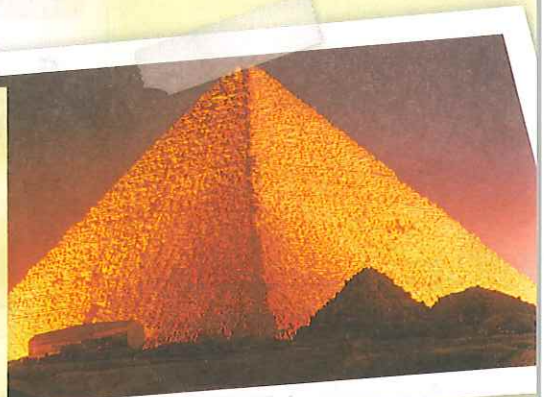
I think this word means...	How does this word fit with other words and concepts I know?
square root	
Are there parts of the word that I recognize?	What makes this an important word for me to know?

What is the relationship between squaring a number and finding the square root? _____

Real-World Link

The square base of the Great Pyramid of Giza covers almost 562,500 square feet. How could you determine the length of each side of the base?

_____



Which MP Mathematical Practices did you use? Shade the circle(s) that applies.

1. Persevere with Problems
2. Reason Abstractly
3. Construct an Argument
4. Model with Mathematics
5. Use Math Tools
6. Attend to Precision
7. Make Use of Structure
8. Use Repeated Reasoning

Essential Question

WHY is it helpful to write numbers in different ways?

Vocabulary

square root
perfect square
radical sign
cube root
perfect cube

Common Core State Standards

Content Standards
8.EE.2

MP Mathematical Practices
1, 3, 4

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Key Concept

Square Root

Watch

Words	A square root of a number is one of its two equal factors.
Symbols	If $x^2 = y$, then x is a square root of y.
Example	$5^2 = 25$ so 5 is a square root of 25.

Every positive number has *both* a positive and negative square root. In most real-world situations, only the positive or *principal* square root is considered. A **radical sign**, $\sqrt{\ }$, is used to indicate the principal square root. If $n^2 = a$, then $n = \pm\sqrt{a}$.

Examples

Tutor

Find each square root.

1. $\sqrt{64}$

$\sqrt{64} = 8$ Find the positive square root of 64; $8^2 = 64$.

2. $\pm\sqrt{1.21}$

$\pm\sqrt{1.21} = \pm 1.1$ Find both square roots of 1.21; $1.1^2 = 1.21$.

Work Zone

Show your work.

3. $-\sqrt{\frac{25}{36}}$

$-\sqrt{\frac{25}{36}} = -\frac{5}{6}$ Find the negative square root of $\frac{25}{36}$; $\left(\frac{5}{6}\right)^2 = \frac{25}{36}$.

4. $\sqrt{-16}$

There is no real square root because no number times itself is equal to -16.

Got it? Do these problems to find out.

a. $\sqrt{\frac{9}{16}}$ b. $\pm\sqrt{0.81}$ c. $-\sqrt{49}$ d. $\sqrt{-100}$

a. _____

b. _____

c. _____

d. _____

Example

Tutor

5. **Solve $t^2 = 169$. Check your solution(s).**

$t^2 = 169$ Write the equation.

$t = \pm\sqrt{169}$ Definition of square root

$t = 13$ and -13 **Check** $13 \cdot 13 = 169$ and $(-13)(-13) = 169$ ✓

Got it? Do these problems to find out.

e. $289 = a^2$ f. $m^2 = 0.09$ g. $y^2 = \frac{4}{25}$

e. _____

f. _____

g. _____

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Cube Roots

Key Concept

Words A **cube root** of a number is one of its three equal factors.

Symbols If $x^3 = y$, then x is the cube root of y.

Numbers such as 8, 27, and 64 are **perfect cubes** because they are the cubes of integers.

$8 = 2 \cdot 2 \cdot 2$ or 2^3 $\quad 27 = 3 \cdot 3 \cdot 3$ or 3^3 $\quad 64 = 4 \cdot 4 \cdot 4$ or 4^3

The symbol $\sqrt[3]{\ }$ is used to indicate a cube root of a number.

If $n^3 = a$, then $n = \sqrt[3]{a}$. You can use this relationship to solve equations that involve cubes.

Examples

Tutor

Find each cube root.

6. $\sqrt[3]{125}$

$\sqrt[3]{125} = 5$ $\quad 5^3 = 5 \cdot 5 \cdot 5$ or 125

7. $\sqrt[3]{-27}$

$\sqrt[3]{-27} = -3$ $\quad (-3)^3 = (-3) \cdot (-3) \cdot (-3)$ or -27

Got it? **Do these problems to find out.**

h. $\sqrt[3]{729}$ **i.** $\sqrt[3]{-64}$ **j.** $\sqrt[3]{1{,}000}$

Show your work.

h. _____

i. _____

j. _____

Real World Example

Tutor

8. **Dylan has a planter in the shape of a cube that holds 8 cubic feet of potting soil. Solve the equation $8 = s^3$ to find the side length s of the container.**

$8 = s^3$ Write the equation.

$\sqrt[3]{8} = s$ Take the cube root of each side.

$2 = s$ Definition of cube root

So, each side of the container is 2 feet.

Check $(2)^3 = 8$ ✓

Cube Roots

While $\sqrt{-16}$ is not a real number, $\sqrt[3]{-27}$ is a real number. $-3 \cdot -3 \cdot -3 = -27$

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Show your work.

k. _____

Got it? Do this problem to find out.

k. An aquarium in the shape of a cube that will hold 25 gallons of water has a volume of 3.375 cubic feet. Solve $s^3 = 3.375$ to find the length of one side of the aquarium.

Guided Practice

Check

Find each square root. (Examples 1–4)

1. $-\sqrt{1.69} =$ _____

Show your work.

2. $\pm\sqrt{\frac{49}{144}} =$ _____

3. $\sqrt{-1.44} =$ _____

Solve each equation. Check your solution(s). (Example 5)

4. $p^2 = 36$ _____

5. $t^2 = \frac{1}{9}$ _____

6. $6.25 = r^2$ _____

Find each cube root. (Examples 6 and 7)

7. $\sqrt[3]{216} =$ _____

8. $\sqrt[3]{-125} =$ _____

9. $\sqrt[3]{-8} =$ _____

10. A cube-shaped packing box can hold 729 cubic inches of packing material. Solve $729 = s^3$ to find the length of one side of the box. (Example 8) _____

11. **Building on the Essential Question** Why would I need to use square roots and cube roots?

_____

_____

_____

_____

Rate Yourself!

☐ I understand how to find square roots and cube roots.

Great! You're ready to move on!

☐ I still have some questions about finding square roots and cube roots.

No Problem! Go online to access a Personal Tutor. Tutor

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Name _____ My Homework _____

Independent Practice

Go online for Step-by-Step Solutions

eHelp

Find each square root. (Examples 1–4)

1. $\sqrt{16} =$ _____

Show your work.

2. $-\sqrt{484} =$ _____

3. $\sqrt{-36} =$ _____

4. $\pm\sqrt{\frac{9}{49}} =$ _____

5. $-\sqrt{2.56} =$ _____

6. $\sqrt{-0.25} =$ _____

Solve each equation. Check your solution(s). (Example 5)

7. $v^2 = 81$ _____

8. $w^2 = \frac{36}{100}$ _____

9. $0.0169 = c^2$ _____

Find each cube root. (Examples 6 and 7)

10. $\sqrt[3]{1{,}728} =$ _____

11. $\sqrt[3]{-0.125} =$ _____

12. $\sqrt[3]{\frac{27}{125}} =$ _____

13. A group of 169 students needs to be seated in a square formation for a yearbook photo. Solve the equation $169 = s^2$ to find how many students should be in each row. (Example 8) _____

14. Chloe wants to build a storage container in the shape of a cube to hold 15.625 cubic meters of hay for her horse. Solve the equation $15.625 = s^3$ to find the length of one side of the container. (Example 8)

_____

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MP Persevere with Problems Given the area of each square, find the perimeter.

15. Area = 121 square inches

16. Area = 25 square feet

17. Area = 36 square meters

H.O.T. Problems Higher Order Thinking

MP Persevere with Problems Find each value.

18. $(\sqrt{36})^2 =$ _____

19. $\left(\sqrt{\frac{25}{81}}\right)^2 =$ _____

20. $(\sqrt{199})^2 =$ _____

21. $(\sqrt{x})^2 =$ _____

22. **MP Reason Abstractly** Based on your solutions to Exercises 18–21, write a rule that could be used to simplify the square of any square root of a number.

23. **MP Reason Inductively** Explain why $\sqrt{-4}$ is not a real number, but $\sqrt[3]{-8}$ is.

24. **MP Reason Inductively** Describe the difference between an exact value and an approximation when finding square roots of numbers that are not perfect squares. Give an example of each.

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Name _____ My Homework _____

Extra Practice

Find each square root.

25. $-\sqrt{81} =$ -9

Homework Help

$9 \cdot 9 = 81$

So, $-\sqrt{81} = -9$.

26. $-\sqrt{\frac{64}{225}} =$ _____

27. $-\sqrt{\frac{16}{25}} =$ _____

28. $\pm\sqrt{1.44} =$ _____

Find each cube root.

29. $\sqrt[3]{-216} =$ _____

30. $\sqrt[3]{-512} =$ _____

31. $\sqrt[3]{-1{,}000} =$ _____

32. $\sqrt[3]{-343} =$ _____

Solve each equation. Check your solution(s).

33. $b^2 = 100$

34. $\frac{9}{64} = c^2$

35. $a^2 = 1.21$

36. $\frac{1}{8} = z^3$

37. $1.331 = c^3$

38. $m^3 = 8{,}000$

39. $\sqrt{x} = 5$

40. $\sqrt{y} = 20$

41. $\sqrt{z} = 10.5$

42. MP **Persevere with Problems** A concert crew needs to set up some chairs on the floor level. The chairs are to be placed in a square pattern consisting of four square sections. If one of the square sections holds 900 chairs, how many chairs will there be along each length of the larger square? _____

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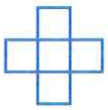
Power Up! Common Core Test Practice

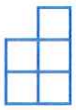
43. Mr. Freeman has a square cornfield. Which of the following could be the area of the cornfield if the sides are measured in whole numbers? Select all that apply.

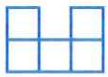
☐ 164,000 ft^2 ☐ 156,816 ft^2 ☐ 174,724 ft^2 ☐ 215,908 ft^2

44. The area of each square in the figures below is 81 square units. Select the perimeter of each figure.

88 units	99 units
90 units	108 units
94 units	117 units







Do any of the figures have the same perimeter? If so, explain why.

Common Core Spiral Review

Evaluate each expression. 8.EE.2

45. $13^3 =$ _____

46. $25^2 =$ _____

47. $15^3 =$ _____

48. $34^2 =$ _____

49. $5 \cdot \sqrt{121} =$ _____

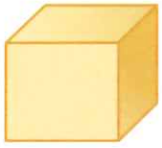
50. $-6 \cdot \sqrt{36} =$ _____

51. $10 \cdot \sqrt[3]{8} =$ _____

52. $-4 \cdot \sqrt{144} =$ _____

Express the volume of each cube as a monomial. 8.EE.1

53.



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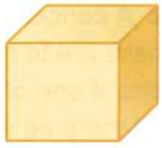
54.



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