

Powers and Exponents

Vocabulary Start-Up



A product of like factors can be written in exponential form using an exponent and a base. The **base** is the number used as a factor. The **exponent** tells how many times a base is used as a factor.

1. Fill in the boxes with the words *factors*, *exponent*, and *base*.

$$\underbrace{10} \times \underbrace{10} = 10^{\left[\quad \right]}$$

\uparrow
 \uparrow

\uparrow
 \uparrow

$\left[\quad \right]$
 $\left[\quad \right]$

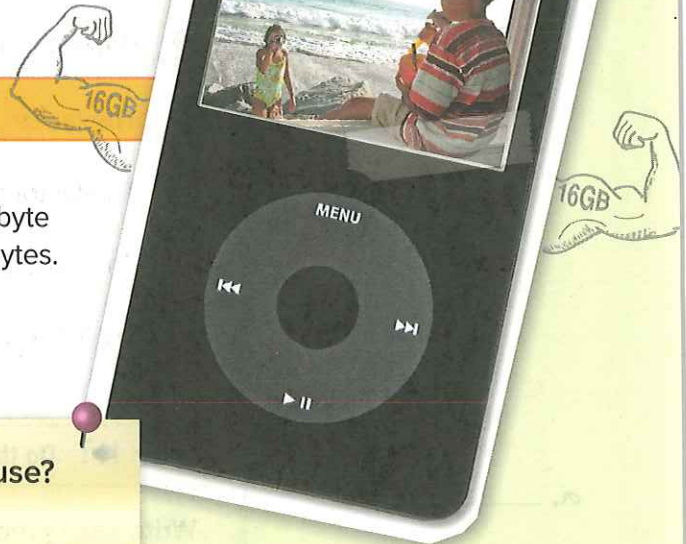
2. Give an example of an exponent.
- _____
3. Write the definition of exponent in your own words.
- _____
- _____



Real-World Link

MP3 players come in different storage sizes, such as 2GB, 4GB, or 16GB, where GB means gigabyte. One gigabyte is equal to $10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$ bytes.

What is this number written with exponents?



Which **MP** Mathematical Practices did you use?

Shade the circle(s) that applies.

- | | |
|--|---|
| <input type="checkbox"/> ① Persevere with Problems | <input type="checkbox"/> ⑤ Use Math Tools |
| <input type="checkbox"/> ② Reason Abstractly | <input type="checkbox"/> ⑥ Attend to Precision |
| <input type="checkbox"/> ③ Construct an Argument | <input type="checkbox"/> ⑦ Make Use of Structure |
| <input type="checkbox"/> ④ Model with Mathematics | <input type="checkbox"/> ⑧ Use Repeated Reasoning |



Essential Question

HOW is it helpful to write numbers in different ways?



Vocabulary

base
exponent
powers
perfect square



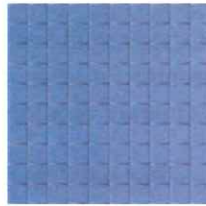
Common Core State Standards

Content Standards
6.EE.1, 6.NS.3

MP Mathematical Practices
1, 3, 4, 6, 8

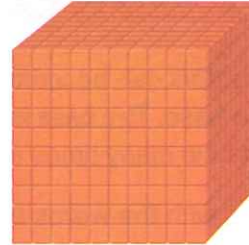
Write Products as Powers

Numbers expressed using exponents are called **powers**. For example, 100 is a power of 10 because it can be written as 10^2 . Numbers like 100 are **perfect squares** because they are the squares of whole numbers.



$$10 \times 10 = 100$$

$$10^2 = 100$$



$$10 \times 10 \times 10 = 1,000$$

$$10^3 = 1,000$$

Perfect cubes are numbers with three identical whole number factors such as $4 \times 4 \times 4 = 64$. So, the number 64 is a perfect cube.

Examples



1. Write $6 \times 6 \times 6 \times 6$ using an exponent.

$$6 \times 6 \times 6 \times 6 = 6^4 \quad \text{6 is used as a factor four times.}$$

2. Write $4 \times 4 \times 4$ using an exponent.

The factor is the base.

The factor is multiplied times.

The exponent is .

So, $4 \times 4 \times 4$ can be written as _____.



a. _____

b. _____

Got It? Do these problems to find out.

Write each product using an exponent.

a. $7 \times 7 \times 7 \times 7$

b. $9 \times 9 \times 9 \times 9 \times 9 \times 9 \times 9$

Write Powers as Products

To write powers as products, determine the base and the exponent. The base of 10^2 is 10 and the exponent is 2. To read powers, consider the exponent. The power 10^2 is read as *ten squared* and 10^3 is read as *ten cubed*.

Examples



3. Write 5^2 as a product of the same factor. Then find the value.

The base is 5. The exponent is 2. So, 5 is used as a factor two times.

$$\begin{aligned} 5^2 &= 5 \times 5 && \text{Write } 5^2 \text{ as a product.} \\ &= 25 && \text{Multiply 5 by itself.} \end{aligned}$$

4. Write 1.5^3 as a product of the same factor. Then find the value.

The base is 1.5. The exponent is 3. So, 1.5 is used as a factor three times.

$$\begin{aligned} 1.5^3 &= 1.5 \times 1.5 \times 1.5 && \text{Write } 1.5^3 \text{ as a product.} \\ &= 3.375 && \text{Multiply.} \end{aligned}$$

5. Write $\left(\frac{1}{2}\right)^3$ as a product of the same factor. Then find the value.

The base is $\frac{1}{2}$. The exponent is 3. So $\frac{1}{2}$ is used as a factor three times.

$$\begin{aligned} \left(\frac{1}{2}\right)^3 &= \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} && \text{Write } \left(\frac{1}{2}\right)^3 \text{ as a product.} \\ &= \frac{1}{8} && \text{Multiply.} \end{aligned}$$

Notation

In Example 5, the fraction $\frac{1}{2}$ is set in parentheses to note that the entire fraction is the base

$$\left(\frac{1}{2}\right)^3 = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$$

Without the parentheses, it is understood that the base is only the numerator of the fraction.

$$\frac{1^3}{2} = \frac{1 \times 1 \times 1}{2} = \frac{1}{2}$$

Show your work.

Got It? Do these problems to find out.

Write each power as a product of the same factor. Then find the value.

c. 10^5

d. 2.1^2

e. $\left(\frac{1}{4}\right)^2$

c. _____

d. _____

e. _____



Example



6. **STEM** The zoo has an aquarium that holds around 7^4 gallons of water. About how many gallons of water does the aquarium hold?

$$7^4 = 7 \times 7 \times 7 \times 7 \quad \text{Write } 7^4 \text{ as a product.}$$

$$= 2,401 \quad \text{Multiply.}$$

So, the aquarium holds about 2,401 gallons of water.

Got It? Do this problem to find out.

- f. **STEM** Michigan has more than 10^4 inland lakes. Find the value of 10^4 .

Show your work.

f. _____

Guided Practice



Write each product using an exponent. (Examples 1 and 2)

1. $8 \times 8 \times 8 =$ _____

2. $1 \times 1 \times 1 \times 1 \times 1 =$ _____

Show your work.

Write each power as a product of the same factor. Then find the value. (Examples 3–5)

3. $\left(\frac{1}{7}\right)^3 =$

4. $2^5 =$

5. $1.4^2 =$

6. Coal mines have shafts that can be as much as 7^3 feet deep. About how many feet deep into Earth's crust are these shafts? (Example 6)
- _____
- _____

7. **e** **Building on the Essential Question** How is using exponents helpful? _____
- _____
- _____

Rate Yourself!

How confident are you about powers and exponents? Shade the ring on the target.



For more help, go online to access a Personal Tutor.



Independent Practice

Go online for Step-by-Step Solutions



Write each product using an exponent. (Examples 1 and 2)

1. $6 \times 6 =$

Show your work.

2. $1 \times 1 \times 1 =$

3. $5 \times 5 \times 5 \times 5 \times 5 \times 5 =$

4. $12 \times 12 =$

5. $27 \times 27 \times 27 \times 27 =$

6. $15 \times 15 \times 15 =$

Write each power as a product of the same factor. Then find the value. (Examples 3–5)

7. $6^4 =$

8. $0.5^3 =$

9. $\left(\frac{1}{8}\right)^2 =$

10. **MP Identify Repeated Reasoning** A byte is a basic unit of measurement for information storage involving computers. (Example 6)

a. A kilobyte is equal to 10^3 bytes. Write 10^3 as a product of the same factor. Then find the value.

b. A megabyte is equal to 10^6 bytes. Write 10^6 as a product of the same factor. Then find the value.

c. How many more bytes of information are in a gigabyte than a megabyte? _____



Find the value of each expression.

11. $0.5^4 + 1 =$ _____

12. $3 \cdot 2^3 \times 10 =$ _____

13. $10 \cdot 3^3 + 8 =$ _____



H.O.T. Problems Higher Order Thinking

14. **MP Model with Mathematics** Write a power whose value is greater than 1,000. _____

15. **MP Persevere with Problems** Use the table to solve.

a. Describe the pattern for the powers of 2.

Write the values of 2^1 and 2^0 in the table.

b. Describe the pattern for the powers of 4.

Write the values of 4^1 and 4^0 in the table. _____

c. Describe the pattern for the powers of 10. Write the values of 10^1 and 10^0 in the table. _____

d. Write a rule for finding the value of any base with an exponent of 0.

16. **MP Be Precise** Multiplication is defined as repeated addition. Use the word repeated to define exponential form. Justify your reasoning.

17. **MP Reason Inductively** Suppose the population of the United States is about 230 million. Is this number closer to 10^7 or 10^8 ? Explain your reasoning.

Powers of 2	Powers of 4	Powers of 10
$2^4 = 16$	$4^4 = 256$	$10^4 = 10,000$
$2^3 = 8$	$4^3 = 64$	$10^3 = 1,000$
$2^2 = 4$	$4^2 = 16$	$10^2 = 100$
$2^1 =$	$4^1 =$	$10^1 =$
$2^0 =$	$4^0 =$	$10^0 =$



Extra Practice

Write each product using an exponent.

18. $6 \times 6 \times 6 = 6^3$

Homework Help

The factor 6 is used 3 times.
The base is 6.
The exponent is 3.

19. $10 \times 10 \times 10 =$

20. $32 \times 32 \times 32 \times 32 =$

21. $9 \times 9 =$

22. $7 \times 7 \times 7 \times 7 \times 7 \times 7 =$

23. $13 \times 13 \times 13 \times 13 \times 13 =$

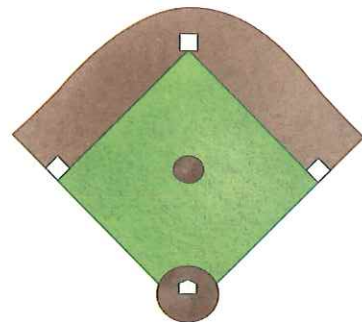
Write each power as a product of the same factor. Then find the value.

24. $3^7 =$

25. $0.06^2 =$

26. $\left(\frac{1}{4}\right)^3 =$

27. **MP Be Precise** The baseball infield at the right has an area of 90^2 square feet. What is the area of the infield?



28. Last week Bakery Marvels baked 5^5 muffins. How many muffins did Bakery Marvels bake?

29. Luke ran 3.5^3 miles in the month of January. How many miles did Luke run in January? _____



Power Up! Common Core Test Practice

30. Mrs. Torrey traveled about $8 \times 8 \times 8 \times 8$ miles from Ohio to Hawaii. Select values to complete the model below to show the repeated multiplication as a power.

2	4
6	8

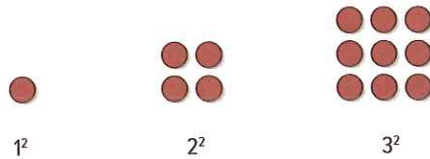
The base is .

The exponent is .

The repeated multiplication can be expressed as the power: .

About how many miles did Mrs. Torrey travel?

31. Claire used counters to make the pattern shown below.



She continues the pattern for several more figures. Which of the following accurately describe how many counters she uses in different figures? Select all that apply.

- There are 25 counters in the 5th figure. There are 81 counters in the 9th figure.
 There are 42 counters in the 6th figure. There are 121 counters in the 11th figure.



Common Core Spiral Review

Multiply or divide. **4.NBT.5, 4.NBT.6**

32. $6 \times 8 =$ _____

33. $64 \div 8 =$ _____

34. $42 \div 7 =$ _____

35. All video games are on sale at The Game House for \$29 each. How much will Bella pay for 3 video games? **4.NBT.5**

36. Max and two of his friends carpooled on a visit to the zoo. The cost of admission was \$12 per person. Parking cost \$7 per car. How much did the group pay on their visit to the zoo? **4.OA.3** _____

