Lesson 4-1
Powers and Exponents

Interactive Study Guide

See pages 73–74 for:
- Getting Started
- Vocabulary Start-Up
- Notes

Essential Question

Why is it useful to write numbers in different ways?

Common Core State Standards

Content Standards
8.EE.1

Mathematical Practices
1, 3, 4, 6, 8

Vocabulary

exponent

power

base

What You'll Learn

- Write expressions using exponents.
- Evaluate expressions containing exponents.

Real-World Link

Computers Data storage capacity is measured in bytes and is based on powers of 2. The standard scientific meanings for the prefixes *mega-* and *giga-* are one million and one billion, respectively. In computer science, a megabyte equals 2^{20} bytes and a gigabyte equals 2^{30} bytes.

Use Exponents

An expression like $5 \cdot 5 \cdot 5$ with equal factors can be written using an exponent. An **exponent** tells how many times a number is used as a factor. A number that is expressed using an exponent is called a **power**. The number that is multiplied is called the **base**. So, $5 \cdot 5 \cdot 5$ equals the power 5^3.

base ⋯➤ 5^3 ◀⋯ exponent

power

Read and Write Powers

Power	Words	Factors
5^1	5 to the first power	5
5^2	5 to the second power or 5 squared	$5 \cdot 5$
5^3	5 to the third power or 5 cubed	$5 \cdot 5 \cdot 5$
5^4	5 to the fourth power or 5 to the fourth	$5 \cdot 5 \cdot 5 \cdot 5$
⋮	⋮	⋮
5^n	5 to the nth power or 5 to the nth	$\underbrace{5 \cdot 5 \cdot 5 \cdot \ldots \cdot 5}_{n \text{ factors}}$

Example 1

Tutor

Write each expression using exponents.

a. $(-8) \cdot (-8) \cdot (-8)$

The base -8 is a factor 3 times.

$(-8) \cdot (-8) \cdot (-8) = (-8)^3$

b. $(k + 2)(k + 2)(k + 2)(k + 2)$

The base $(k + 2)$ is a factor 4 times.

$(k + 2)(k + 2)(k + 2)(k + 2) = (k + 2)^4$

c. $5 \cdot r \cdot r \cdot s \cdot s \cdot s \cdot s$

$5 \cdot r \cdot r \cdot s \cdot s \cdot s \cdot s = 5 \cdot (r \cdot r) \cdot (s \cdot s \cdot s \cdot s)$ Group factors with like bases.

$= 5 \cdot r^2 \cdot s^4$ or $5r^2s^4$ $r \cdot r = r^2, s \cdot s \cdot s \cdot s = s^4$

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

Got It? Do these problems to find out.

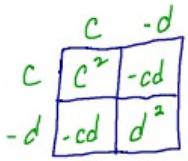
1a. $\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \left(\frac{1}{2}\right)^3$

1b. $x \cdot x \cdot x \cdot x \cdot x = x^5$

1c. $(c - d)(c - d) = (c-d)^2$

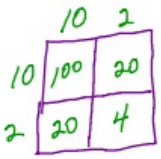
1d. $9 \cdot f \cdot f \cdot f \cdot f \cdot g$

$(c-d)^2$



$c^2 - cd - cd + d^2 = c^2 - 2cd + d^2$

$12^2 = 144$



$100 + 20 + 20 + 4 = 144$

Evaluate Expressions

Vocabulary Link
Evaluate
Everyday Use Determine the significance or worth of something.
Math Use Find the value of an expression.

Since powers represent repeated multiplication, they need to be included in the rules for order of operations.

Concept Summary Order of Operations

Step 1	Simplify the expressions inside grouping symbols.
Step 2	Evaluate all powers. TURBO MULTIPLICATION
Step 3	Multiply and/or divide in order from left to right.
Step 4	Add and/or subtract in order from left to right.

Example 2

Tutor

Exponents
An exponent goes with the number, variable, or quantity in parentheses immediately preceding it.

The playing area for beach volleyball includes the playing court and the free zone. Evaluate each expression to find the area of the playing court and the free zone.

a. The playing court is a rectangle with an area of 2^7 square meters.

$2^7 = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$ 2 is a factor 7 times.
$= 128$ Simplify.

The area of the playing court is 128 square meters.

b. The area of the free zone is $2^2 \cdot 3^2 \cdot 5$ square meters.

$2^2 \cdot 3^2 \cdot 5 = 2 \cdot 2 \cdot 3 \cdot 3 \cdot 5$ Evaluate powers.
$= 180$ Multiply.

The area of the free zone is 180 square meters.

Got It? Do this problem to find out.

2. STEM A tennis ball is dropped from the top of a building. After 8 seconds, the tennis ball hits the ground. The distance in meters the ball traveled is represented by $4.9(8)^2$. How far did the ball drop? $4.9(64) = 313.6$

Example 3

Tutor

Watch Out!
$(-3)^2$ is not the same as -3^2.
- $(-3)^2 = (-3)(-3) = 9$
- $-3^2 = (-1)(3^2) = -9$

Evaluate $x^2 + y^3$ if $x = 6$ and $y = -2$.

$x^2 + y^3 = 6^2 + (-2)^3$ Replace x with 6 and y with -2.
$= 36 - 8$ Evaluate powers; $6^2 = (6 \cdot 6)$ or 36; $(-2)^3 = (-2)(-2)(-2)$ or -8.
$= 28$ Subtract.

$b^2 \rightarrow (-2)^2$ $-2^2 = -4$

Got It? Do these problems to find out.

Evaluate each expression if $a = 5$, $b = -2$, and $c = \frac{3}{4}$.

3a. $10 + b^2$ $10 + (-2)^2$ $10 + 4 = 14$

3b. $(a + b)^3$ $(5 + -2)^3$ $3^3 = 27$

3c. $2 - c^2$ $2 - \left(\frac{3}{4}\right)^2$ $\frac{3}{4}\left(\frac{3}{4}\right) = \frac{9}{16}$ $2 - \frac{9}{16} = 1\frac{7}{16}$ $1\frac{16}{16} - \frac{9}{16} = 1\frac{7}{16}$