

Grade 8 - Properties of Integer Exponents - Lesson

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An integer exponent tells how many times a base is multiplied by itself, or divided if the exponent is negative. To multiply powers with the same base, add the exponents; to divide, subtract them; for a power of a power, multiply them. Also, a nonzero base to the zero power equals 1.

Grade 8 · Common Core State Standards: **8.EE.A.1**

Key facts

- Product rule: $a^m \cdot a^n = a^{m+n}$.
- Quotient rule: $\frac{a^m}{a^n} = a^{m-n}$.
- Power rule: $(a^m)^n = a^{mn}$.
- $a^0 = 1$ and $a^{-n} = \frac{1}{a^n}$ for nonzero a .
- A negative exponent does not make the number negative: $2^{-3} = \frac{1}{8}$.

What is an exponent?

An exponent tells how many times a base is used as a factor. In 2^5 , the base is 2 and the exponent is 5, so $2^5 = 2 \times 2 \times 2 \times 2 \times 2 = 32$. Integer exponents can also be zero or negative.

The five exponent properties

For nonzero a and integers m and n : **Product** $a^m \cdot a^n = a^{m+n}$. **Quotient** $\frac{a^m}{a^n} = a^{m-n}$. **Power** $(a^m)^n = a^{mn}$. **Zero** $a^0 = 1$. **Negative** $a^{-n} = \frac{1}{a^n}$.

Why does the product rule add exponents?

Count the factors. 3^4 is four 3s and 3^2 is two more 3s, so the product has six 3s.



3^4 : 4 factors 3^2 : 2 factors

Together: 6 factors, so 3^6

$$3^4 \times 3^2 = 3^6$$

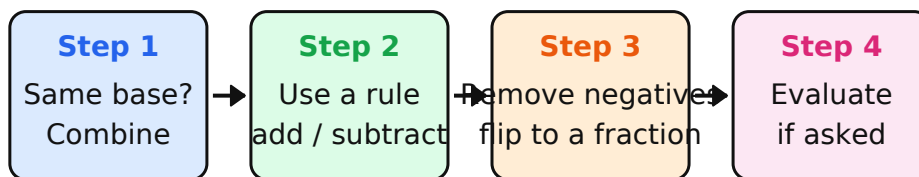
Why is a zero or negative exponent defined that way?

Look at the pattern in powers of 2. Each step to the right divides by 2, so the exponent drops by 1. Keep the pattern going and you reach $2^0 = 1$, then $2^{-1} = \frac{1}{2}$, $2^{-2} = \frac{1}{4}$, and so on.

2^4 16	2^3 8	2^2 4	2^1 2	2^0 1	2^{-1} $\frac{1}{2}$	2^{-2} $\frac{1}{4}$	2^{-3} $\frac{1}{8}$
	$\div 2$	$\div 2$	$\div 2$	$\div 2$	$\div 2$	$\div 2$	$\div 2$

Each step to the right divides by 2, so the exponent drops by 1.

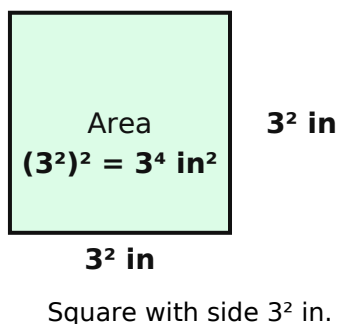
How do you simplify an expression with exponents?



Work through the four steps in order.

1. Group the powers that have the same base.
2. Apply the product, quotient, or power rule.
3. Rewrite negative exponents as fractions.
4. Evaluate if the question asks for a number.

Worked example. Simplify $\frac{5^3 \cdot 5^{-5}}{5^{-2}}$. The numerator is $5^{3+(-5)} = 5^{-2}$. Then $\frac{5^{-2}}{5^{-2}} = 5^{-2-(-2)} = 5^0 = 1$.



Area is a good check for the power rule: a square with side $3^2 = 9$ inches has area $9^2 = 81 = 3^4$ square inches, so $(3^2)^2 = 3^4$. Watch the signs: $(-2)^2 = 4$ but $-2^2 = -4$.

Powers of 10 are everywhere. A meter has $10^2 = 100$ centimeters, and a millimeter is 10^{-3} meter. When you multiply $10^4 \cdot 10^{-6}$, you add the exponents to get 10^{-2} , which is 0.01. Practice the rules until each one feels automatic, and always check the sign of the exponent first.

Questions about properties of integer exponents

Why does any nonzero number to the zero power equal 1?

Use the quotient rule: $\frac{5^3}{5^3} = 1$ and also $5^{3-3} = 5^0$. Both must be equal, so $5^0 = 1$.

Does a negative exponent make the answer negative?

No. It makes the power a reciprocal. For example $4^{-2} = \frac{1}{4^2} = \frac{1}{16}$, which is positive.

Can I add exponents when the bases are different?

No. The product rule only works for the same base. $2^3 \cdot 3^2 = 8 \cdot 9 = 72$ and cannot be written as one power.

What is the difference between $(-3)^2$ and -3^2 ?

$(-3)^2 = 9$ because the base is -3 . $-3^2 = -9$ because only 3 is squared and then the result is negated.

How do I simplify a power of a fraction with a negative exponent?

Flip the fraction and make the exponent positive: $\left(\frac{2}{3}\right)^{-2} = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$.