

# Exponential Terms Raised to an Exponent

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# 5.2 Exponential Terms Raised to an Exponent

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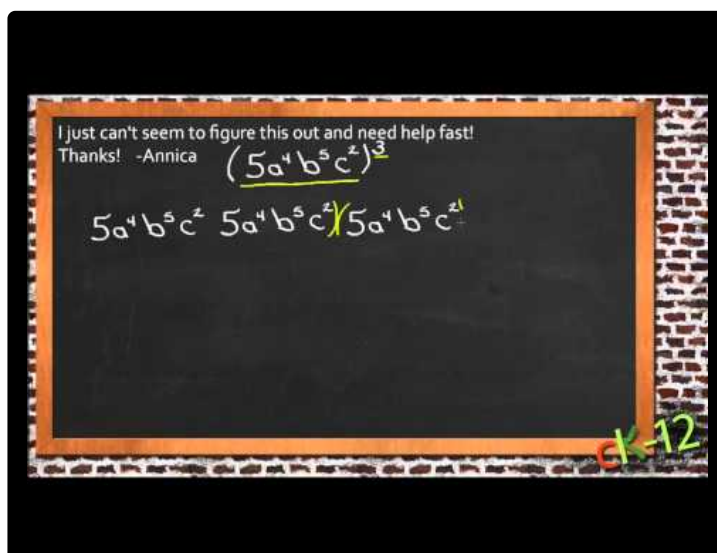
## Exponential Terms Raised to an Exponent

What happens when we raise a whole **expression** to a power? Let's take  $x$  **to the power of 4** and **cube it**. Again we'll use the full **factored form** for each expression:

$$(x^4)^3 = x^4 \times x^4 \times x^4 \quad \text{3 factors of \{x to the power 4\}}$$

$$(x \cdot x \cdot x \cdot x) \cdot (x \cdot x \cdot x \cdot x) \cdot (x \cdot x \cdot x \cdot x) = x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x = x^{12}$$

So  $(x^4)^3 = x^{12}$ . You can see that when we raise a power of  $x$  to a new power, the powers multiply.



<https://flexbooks.ck12.org/flx/render/embeddedobject/133164>

**Power Rule for Exponents:**  $(x^n)^m = x^{(n \cdot m)}$

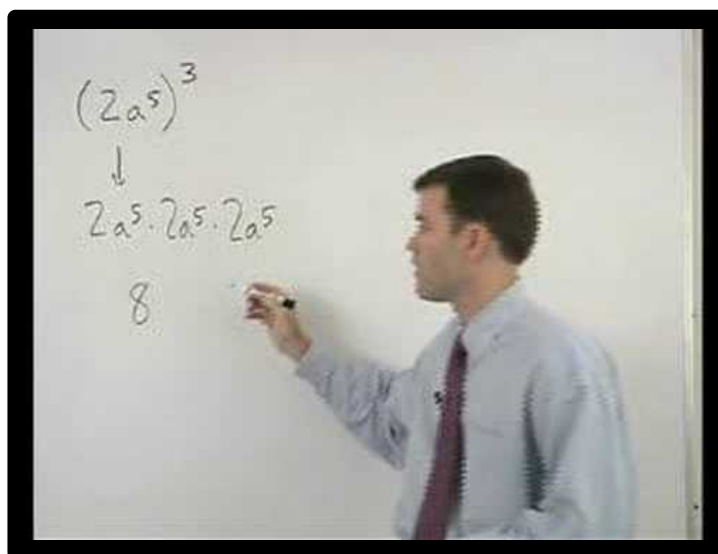
If we have a product of more than one **term** inside the **parentheses**, then we have to distribute the **exponent** over all the factors, like distributing **multiplication** over **addition**. For example:

$$(x^2y)^4 = (x^2)^4 \cdot (y)^4 = x^8y^4.$$

Or, writing it out the long way:

$$\begin{aligned}(x^2y)^4 &= (x^2y)(x^2y)(x^2y)(x^2y) = (x \cdot x \cdot y)(x \cdot x \cdot y)(x \cdot x \cdot y)(x \cdot x \cdot y) \\ &= x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot y \cdot y \cdot y \cdot y = x^8y^4\end{aligned}$$

Note that this does NOT work if you have a sum or **difference** inside the parentheses! For example,  $(x + y)^2 \neq x^2 + y^2$ . This is an easy mistake to make, but you can avoid it if you remember what an exponent **means**: if you multiply out  $(x + y)^2$  it becomes  $(x + y)(x + y)$ , and that's not the same as  $x^2 + y^2$ . We'll learn how we can simplify this expression in a later chapter.



<https://flexbooks.ck12.org/flx/render/embeddedobject/21510>

## Simplifying Expressions

1. Simplify the following expressions.

When we're just working with numbers instead of variables, we can use the product rule and the power rule, or we can just do the multiplication and then simplify.

a)  $3^5 \cdot 3^7$

We can use the product rule first and then **evaluate** the result:  $3^5 \cdot 3^7 = 3^{12} = 531441$ .

OR we can evaluate each part separately and then multiply them:

$$3^5 \cdot 3^7 = 243 \cdot 2187 = 531441.$$

b)  $2^6 \cdot 2$

We can use the product rule first and then evaluate the result:  $2^6 \cdot 2 = 2^7 = 128$ .

OR we can evaluate each part separately and then multiply them:  $2^6 \cdot 2 = 64 \cdot 2 = 128$ .

c)  $(4^2)^3$

We can use the power rule first and then evaluate the result:  $(4^2)^3 = 4^6 = 4096$ .

OR we can evaluate the expression inside the parentheses first, and then apply the exponent outside the parentheses:  $(4^2)^3 = (16)^3 = 4096$ .

2. Simplify the following expressions.

When we're just working with variables, all we can do is simplify as much as possible using the product and power rules.

a)  $x^2 \cdot x^7$

$$x^2 \cdot x^7 = x^{2+7} = x^9$$

b)  $(y^3)^5$

$$(y^3)^5 = y^{3 \times 5} = y^{15}$$

3. Simplify the following expressions.

When we have a mix of numbers and variables, we apply the rules to each number and **variable** separately.

a)  $(3x^2y^3) \cdot (4xy^2)$

First we group **like terms** together:  $(3x^2y^3) \cdot (4xy^2) = (3 \cdot 4) \cdot (x^2 \cdot x) \cdot (y^3 \cdot y^2)$

Then we multiply the numbers or apply the product rule on each grouping:  $= 12x^3y^5$

b)  $(4xyz) \cdot (x^2y^3) \cdot (2yz^4)$

Group like terms together:

$$(4xyz) \cdot (x^2y^3) \cdot (2yz^4) = (4 \cdot 2) \cdot (x \cdot x^2) \cdot (y \cdot y^3 \cdot y) \cdot (z \cdot z^4)$$

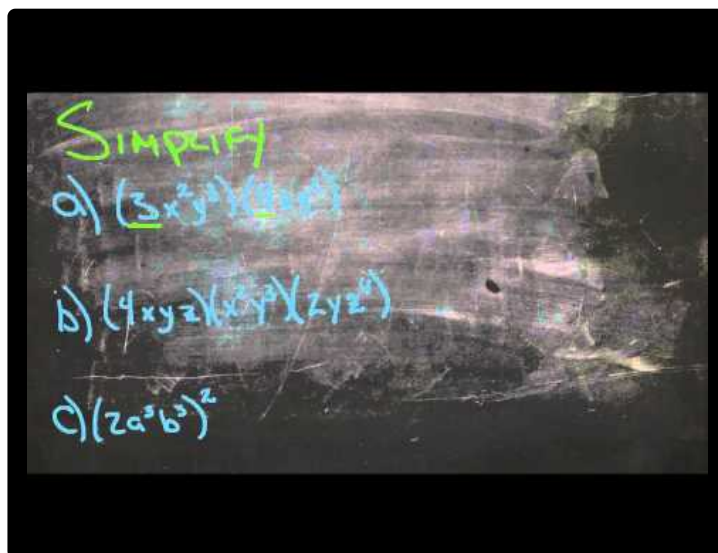
Multiply the numbers or apply the product rule on each grouping:  $= 8x^3y^5z^5$

c)  $(2a^3b^3)^2$

Apply the power rule for each separate term in the parentheses:

$$(2a^3b^3)^2 = 2^2 \cdot (a^3)^2 \cdot (b^3)^2$$

Multiply the numbers or apply the power rule for each term  $= 4a^6b^6$



<https://flexbooks.ck12.org/flx/render/embeddedobject/133165>

## Examples

Simplify the following expressions.

In problems where we need to apply the product and power rules together, we must keep in mind the **order of operations**. Exponent **operations** take precedence over multiplication.

### Example 1

$$(x^2)^2 \cdot x^3$$

We apply the power rule first:  $(x^2)^2 \cdot x^3 = x^4 \cdot x^3$

Then apply the product rule to combine the two terms:  $x^4 \cdot x^3 = x^7$

### Example 2

$$(2x^2y) \cdot (3xy^2)^3$$

Apply the power rule first:  $(2x^2y) \cdot (3xy^2)^3 = (2x^2y) \cdot (27x^3y^6)$

Then apply the product rule to combine the two terms:  $(2x^2y) \cdot (27x^3y^6) = 54x^5y^7$

### Example 2

$$(4a^2b^3)^2 \cdot (2ab^4)^3$$

Apply the power rule on each of the terms separately:

$$(4a^2b^3)^2 \cdot (2ab^4)^3 = (16a^4b^6) \cdot (8a^3b^{12})$$

Then apply the product rule to combine the two terms:  $(16a^4b^6) \cdot (8a^3b^{12}) = 128a^7b^{18}$

## Review

Simplify:

1.  $(a^3)^4$
2.  $(xy)^2$
3.  $(-5y)^3$
4.  $(3a^2b^3)^4$
5.  $(-2xy^4z^2)^5$
6.  $(-8x)^3(5x)^2$
7.  $(-x)^2(xy)^3$
8.  $(4a^2)(-2a^3)^4$
9.  $(12xy)(12xy)^2$
10.  $(2xy^2)(-x^2y)^2(3x^2y^2)$

## Review (Answers)

To see the review answers, return to the [Table of Contents](#) and select 'Other Versions' or 'Resources'.

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