

8.EE.1 Know and apply the properties of integer exponents to generate equivalent numerical expressions.

For example, $3^2 \times 3^{-5} = 3^{-3} = (\frac{1}{3})^3 = \frac{1}{27}$.

Mechanics

Teacher Notes: This standard follows from 6.EE.1 and 6.EE.2.c. There are no Level 7 standards which directly address exponents. Because of this gap, some review of exponents is recommended before introducing this standard.

In addition, students often have greater success applying exponents to variables than they do applying them to integers. A common misconception is to multiply the exponent by the base. Review of exponents and how they're applied to integers will facilitate success with this standard.

This standard covers the following properties involving operations with exponents.

- *Addition and subtraction of terms*
- *Product and quotient rules*
- *Raising a product and a quotient to a power*
- *Raising a power to a power*
- *Raising to a power of 0*
- *Negative exponents*

Addition and Subtraction of Terms

In order to add or subtract exponential terms, they must have both the same base as well as the same exponent. (Only the coefficient can be different.) Terms that have both the same base and the same power are called like terms. The addition and/or subtraction of like terms is commonly referred to as "combining like terms."

Simplify $2a^2 - 3a + 5a$.

This expression contains 3 terms: $2a^2$, $-3a$, and $+5a$. Of these, two are like terms, $-3a$, and $+5a$, which can be combined; the "unlike" terms can't be changed and are left as is.

When like terms are combined, the base and the power are kept the same and the coefficients are added (or subtracted).

$-3a$, and $+5a = +2a$

So, overall, the original expression can be simplified to $2a^2 + 2a$.

There is no limit to the number or type of terms that can be combined in this way.

Examples:

Simplify $7 - x - 3 + 4x$.

$$7 - 3 - x + 4x \\ 4 + 3x$$

The first step is to group like terms together.

Remember: Constants (integers without a variable) are also like terms.

Simplify $2x^2 + 3y + x^2 - 2y + 3y^2$.

$$2x^2 + x^2 + 3y - 2y + 3y^2 \\ 3x^2 + y + 3y^2$$

Remind students that if a variable is written without a coefficient, it is the same as having a coefficient of 1. That is, $x^2 = 1x^2$.

Product of Powers

Find $y^2 \times y^4$.

It is easy to understand this problem if you expand it first. $y^2 = y \times y$; $y^4 = y \times y \times y \times y$. So now you have the following:

$$y^2 \times y^4 = (y \times y) \times (y \times y \times y \times y) = y \times y \times y \times y \times y \times y = y^6$$

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

This process could be very time consuming. However, if we notice the relationship between the exponents that are being multiplied together and the exponent of the product, we can avoid writing it out each time.

By definition, $a^n \times a^m = a^{(n+m)}$.

$$y^2 \times y^4 = y^{2+4} = y^6$$

So, when multiplying exponents, simply add the exponents and keep the base. It is extremely important that students understand this — you can only add the exponents when they have the same base. (If the problem were $x^2 \times y^4$, there are two different bases, x and y , so they could not be simplified this way.)

There are other equivalent ways to show that exponents are being multiplied, e.g. $(y^2)(y^4) = y^{(2+4)} = y^6$.

Find $a^{-5} \times a^3$.

In this example, one of the exponents is negative. The same rules apply.

$$a^{-5} \times a^3 = a^{(-5+3)} = a^{-2} = \frac{1}{a^2}$$

Quotient of Powers

Now, let's talk about dividing with exponents.

Find $y^2 \div y^4$.

Remember that a fraction is another way to write a division problem. Write it as a fraction and then expand it.

$$\frac{y^2}{y^4} = \frac{y \times y}{y \times y \times y \times y}$$

Then, begin canceling out ys until either the numerator or denominator runs out.

$$\frac{\cancel{y} \times \cancel{y}}{\cancel{y} \times \cancel{y} \times y \times y} = \frac{1}{y \times y} = \frac{1}{y^2} = y^{-2}$$

By definition, $a^n \div a^m = a^{(n-m)}$.

In other words, $y^2 \div y^4 = y^{(2-4)} = y^{-2}$. Notice the relationship between the exponents of the dividend and divisor and the exponent of the quotient. $2 - 4 = -2$.

$$y^2 \div y^4 = y^{2-4} = y^{-2}$$

Therefore, whenever you divide numbers with exponents, you keep the base and subtract the exponents. Just as we saw with multiplication, this is only true when the exponents have the same base. (In the example above, the base is y.)

Remind student that there are other ways to show division such that exponents are being subtracted (e.g. $\frac{x^5}{x^2} = x^{(5-2)} = x^3$).

Raising a Product or a Quotient to a Power $(ab)^x = a^x \times b^x$ or $(\frac{a}{b})^x = \frac{a^x}{b^x}$

When a product is raised to a power, the exponent is applied to each factor.

Simplify $(ab)^2$.

$$(ab)^2 = a^2 \times b^2$$

Simplify $(3x)^3$.

$$(3x)^3 = 3^3 \times x^3 = 27x^3$$

In a similar way, a power is applied to a quotient. When a quotient is raised to a power, the exponent is applied to both the dividend and the divisor.

Simplify $(\frac{a}{b})^2$.

$$(\frac{a}{b})^2 = \frac{a^2}{b^2}$$

Simplify $(\frac{3x}{2})^4$.

$$\frac{(3x)^4}{2^4} = \frac{3^4 \times x^4}{16} = \frac{81x^4}{16}$$

The rule is $(\frac{a}{b})^n = \frac{a^n}{b^n}$. (It is important for students to distinguish between $(\frac{a}{b})^n$ and $\frac{a^n}{b}$ and $\frac{a}{b^n}$. Confusion of these often leads to errors. There must be parentheses if the entire fraction is raised to a power.)

Raising a Power to a Power $(a^x)^y = a^{xy}$

Find $(y^2)^4$.

It is easy to understand this problem if you expand it first.

$$(y^2)^4 = (y \times y) (y \times y) (y \times y) (y \times y) = y \times y \times y \times y \times y \times y \times y \times y = y^8$$

So now you have the following:

$$(y^2)^4 = y^8$$

Again, this could become very time consuming. However, if we notice the relationship between the exponent that is raised to a power, we can avoid writing it out each time.

By definition, $(a^x)^y = a^{(xy)}$. When a power is raised to a power, keep the base and multiply the exponents.

Find $(2y^2)^5$.

$$(2y^2)^5 = 2^5 y^{(2 \times 5)} = 32y^{10}$$

Find $((2y)^2)^5$.

$$((2y)^2)^5 = (2y)^{2 \times 5} = (2y)^{10} = 2^{10} \times y^{10} = 1,024y^{10}$$

Raising to a Power of Zero $a^0 = 1$

This is a rule that is simple to memorize but can be explained by applying the quotient of powers rules. According to the quotient of powers rule:

$$\frac{a^5}{a^5} = a^{5-5} = a^0$$

We also know that any number divided by itself is equal to 1.

$$\frac{a^5}{a^5} = 1$$

Therefore, $\frac{a^5}{a^5} = 1$.

Find $(2y)^0 = 1$

Find $(3x^2 + y + 3y^2)^0 = 1$

Find $658^0 = 1$

(Be careful of parentheses, however!) $2y^0 = 2 \times y^0 = 2 \times 1 = 2$

Negative Exponents $a^{-b} = \frac{1}{a^b}$ and $a^b = \frac{1}{a^{-b}}$

Negative exponents are an extension of the quotient rule.

If we look at $\frac{y^2}{y^6}$, we see that $\frac{y^2}{y^6} = y^{2-6} = y^{-4}$.

Another way to look at this is by expanding the fraction.

$$\frac{y^2}{y^6} = \frac{\cancel{y} \times \cancel{y}}{\cancel{y} \times \cancel{y} \times y \times y \times y \times y} = \frac{1}{y \times y \times y \times y} = \frac{1}{y^4}$$

This tells us that $y^{-4} = \frac{1}{y^4}$

Find $\left(\frac{1}{3}\right)^{-2}$. $\left(\frac{1}{3}\right)^{-2} = \left(\frac{3}{1}\right)^2 = \frac{3^2}{1^2} = 9$

Find 3^{-3} . $3^{-3} = \frac{3^{-3}}{1} = \frac{1}{3^3} = \frac{1}{3 \times 3 \times 3} = \frac{1}{27}$

Find $\left(\frac{2}{5}\right)^{-3}$. $\left(\frac{2}{5}\right)^{-3} = \left(\frac{5}{2}\right)^3 = \frac{5^3}{2^3} = \frac{125}{8}$

Simple Solutions Common Core Math 8 Examples

Simplify. $\frac{p^8 q^4}{p^2 q^5}$

$$\frac{p^6}{q} \text{ or } p^6 q^{-1}$$

Simplify using exponential notation: $3b^3 \times 5b^4$

$$15b^7$$

Simplify using exponential notation: $12^3 \times 12^3 \times 12^2$

$$12^8$$

Write using only positive exponents. $\frac{f^{-8}}{f^{-3}}$

$$\frac{f^3}{f^5} = \frac{1}{f^2}$$

Simplify using only positive exponents. $(4p)^{-3}$

$$\frac{1}{64p^3}$$

Simplify. $\frac{5^8 x^6}{5^5 x^7}$

$$\frac{5^3}{x} = \frac{125}{x} \text{ or } 125x^{-1}$$

Finally, students will need to solve problems that mix numerals and variables. Instruct students that like bases are multiplied (i.e. numerals to numerals and matching variables to matching variables, such as y to y).

Simplify $4y^2 \times 6y^5$.

Group like terms together. $4y^2 \times 6y^5 = 4(6) \times (y^2)(y^5) = 24y^{(2+5)}$

$$24y^7$$

Simplify $\frac{10x^5y^3}{4x^2y^4}$ using exponential notation.

$$\frac{5x^3}{2y} \text{ or } \frac{5}{2}x^3y^{-1}$$

Simplify $\frac{7^{21}m^6}{7^4m^{40}}$.

$$\frac{7^{17}}{m^{34}} \text{ or } 7^{17}m^{-34}$$

Concept Mastery

- ✓ Students are able to apply the properties of operations involving both positive and negative exponents modifying the same base. (The base in this case might be a variable or a numeral.)
- ✓ Students are able to apply the properties of operations involving both positive and negative exponents in problems involving multiple bases. (The bases in this case might be all variables, all numerals, or a mixture.)

Web Resources* Always preview websites and videos prior to use with students. For more information, see the "Internet Content Tips & Cautions" document.

Broken link? [Click Here](#) to let us know!

Teacher Background

[Exponential Growth](#)

[Algebra in Simplest Terms](#) Exponents begin with Video #3

[Exponents and Logarithms](#)

[Insights Into Algebra](#)

Class Demo & Activities

[Animated Exponent Presentation](#) You may have to close an ad or two early in the presentation; the music ends a bit before the end

[Know and Apply the Properties of Integer Exponents to Generate Equivalent Numerical Expressions](#) 10 mini video lessons

[Understanding Negative Exponents, Bases, and Scientific Notation](#) 5 mini video lessons (skip last 2 dealing with Scientific Notation until 8.EE.3)

[Evaluating Expressions with Exponents](#) 6 mini video lessons

[Exponents Lesson with Worksheet](#)

[Simplifying Multiplication Lesson](#) Includes exponents

[Exponents of Variables Lesson](#)

[Simplifying Negative Exponents Lesson](#)

[Simplifying Fractions With Negative Exponents Lesson](#)

[Order of Operations with Exponents Worksheet Generator](#) *Generates a unique worksheet each time.*

[Exponents <, > Worksheet Generator](#) *Generates a unique worksheet each time.*

[Exponential Notation on a Scientific Calculator](#)

[Review of Exponents](#)

[Multiplying Powers Rule](#)

[Dividing Powers Rule](#)

[Power to a Power](#)

[Powers of Products](#)

[Student Activity with Exponents](#)

Student Practice

[Exponents of Numbers Online Worksheet](#)

[Exponent Review Gears](#)

[Multiplication with Exponents Online Worksheet](#) *Includes step by step guide and self-checking.*

[Negative Exponents Online Worksheet](#) *Self Checking*

[Exponents of Variables Online Worksheet](#)

[Negative Exponents in Fractions Online Worksheet](#)

[That Quiz: Exponents](#) *Select Exponents, n^{-a} , $n^a \times n^a$ and Level.*

[Exponent Rules](#)

[Otter Rush Exponent Game](#)

[Exponents Online Quiz](#)

[Order of Operations with Exponents Online Quiz](#) *NOTE: An exponent is noted by a little space between the base and the exponent in the problems.*

[Raising to Powers by Repeated Multiplication](#)

[Squaring a Number I](#)

[Squaring a Number II](#)

[Cube of a Number](#)

[Evaluating Exponents](#)

[Evaluating Exponents of Negative Numbers](#)

[Exponents Quiz](#)

[Math is Fun Exponents: Mini Lesson & Problems](#)

[Tic Tac Toe Squares](#) *Select levels with squares and cubes.*

[Exponent Basketball Interactive](#)

[Exponent Matching](#)

[PEMDAS Practice](#) *Select Level 4 from the Auto Create Menu*

[Laws of Exponents Archaeological Dig](#)

[Multiplying Powers of the Same Base: Lesson & Problems](#)

[Dividing Powers of the Same Base: Lesson & Problems](#)

[Multiplying Powers of the Same Base Online Quiz](#)

[Dividing Powers of the Same Base Online Quiz](#)

[Practice with Exponents Numerical](#)

[Practice with Exponents: Algebraic](#)

[Applied Practice with Powers](#)

[Practice with Exponent Shorthand](#)

[Exponent Matching Game](#)

[Exponent Game](#)

[Exponents Jeopardy Game](#)

[Exponents Lesson & Problems](#)

[Exponents & Radicals](#)

[Calculating Exponents](#)

[Exponents](#)

* The Web Resources are links to websites that are neither created nor published by Simple Solutions. Simple Solutions has no control over the content of these websites, and the material contained therein does not necessarily reflect the views and opinions of Simple Solutions. The school and classroom teacher are responsible for abiding by the terms of use for each website. Links were set up to open in Internet Explorer and may not open in other browsers.

References

National Governors Association Center for Best Practices, Council of Chief State School Officers. *Common Core State Standards, Mathematics*. Washington, D.C.: National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington, D.C., 2010.

<http://www.corestandards.org/Math>

"Arizona's Common Core Standards." *Arizona Department of Education*. 2010. June.

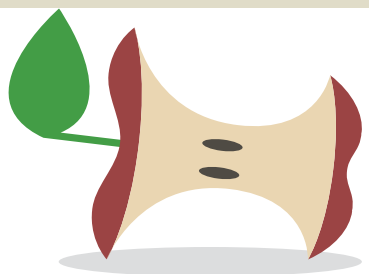
<http://www.azed.gov/standards-practices/mathematics-standards/>

"Common Core State and NC Essential Standards." *Public Schools of North Carolina State Board of Education*. 2010. June.

<http://www.ncpublicschools.org/acre/standards/common-core-tools/>

"Common Core Standards in Mathematics." *Tennessee Department of Education*. 2010. July.

http://www.readtennessee.org/math/teachers/k-3_common_core_math_standards.aspx



**Simple
Solutions.** 

Minutes a Day—Mastery for a Lifetime!