8th Grade Math

Lesson: April 8th

Learning Target:

Students will apply the properties of integer exponents to generate equivalent expressions.

Lesson Includes:

1) Converting between expanded and exponential form
2) Six different exponent rules

Warm Up Activity

Multiply. Write in simplest form:

1) (2)(2)(2)(2)

2) (-3)(-3)(-3)(-3)

3) (½) (½)

4) Mark separated a number of coins into five piles with seven coins in each pile. Mark calculates the number of coins using 5 x 7, but his friend calculates the number of coins using 7 x 5. Are both of them correct? Explain.

Warm Up Activity Answers

Multiply. Write in simplest form:

1) (2)(2)(2)

8

2) (-3)(-3)(-3)(-3)

81

3) (½) (½)

¼

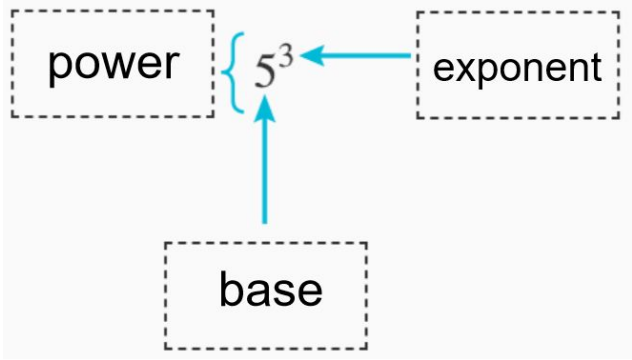
4) Mark separated a number of coins into five piles with seven coins in each pile. Mark calculates the number of coins using 5 x 7, but his friend calculates the number of coins using 7 x 5. Are both of them correct? Explain.

Yes, because commutative property of multiplication states that a x b = b x a. In this case, 5 x 7 = 35 and 7 x 5 = 35 which proves the commutative property.

Instruction: Exponents

Read through the vocabulary.

1) An **exponent**
   - tells how many times a number is repeated using multiplication
2) The **base**
   - the number that is used as a factor
3) A **power**
   - an expression that has two parts: base and an exponent
4) **Expanded form**
   - the expression represented as represented as repeated multiplication
5) **Exponential form**
   - the expression is simplified and uses exponents



Practice: Exponents

Write each expression using exponents:

1. $y \cdot y \cdot y \cdot y \cdot y \cdot y \cdot y$

2. $3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 \cdot 3$

Write each expression **without** using exponents:

3. t^{13}

4. 5^5

Answer: 1. y^7 **2.** 3^{10} **3.** $t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t \cdot t$ **4.** $5 \cdot 5 \cdot 5 \cdot 5 \cdot 5$

Practice: Exponents - Vocabulary

Match the following vocabulary work with its definition:

a. Exponent

b. Base

c. Properties of Exponents

1. What number is being multiplied

2. Rules for operations with exponents

3. How many times a number is being multiplied

Practice: Exponents - Vocabulary **ANSWERS**

Match the following vocabulary work with its definition:

a. Exponent

b. Base

c. Properties of Exponents

1. What number is being multiplied
2. Rules for operations with exponents
3. How many times a number is being multiplied

Instruction: Exponent Rule 1 - Product of Powers

Read through the explanation of the exponent rule: Product of Powers, then watch the video.

Product of Powers Property video linked here.

Product of Powers

$$a^m \cdot a^n = a^{m+n}$$

Bases must be the same.

Bases seen more than once.

Exponents ADD together.

Multiply coefficients, if present.

EXAMPLES:

Simplify each expression.

$a^1 \cdot a^2 \cdot a^3$

a^6

$t^{-4} \cdot t^6$

t^2

$2a^2 \cdot 3a^4$

$6a^6$

$3x^3 \cdot 3x^{-2}$

$3^2 x$

$9x$

$3b^3c \cdot 4b^2c^5$

$12b^5c^6$

$x^2 \cdot x^3 = x \cdot x \cdot x \cdot x \cdot x$

$= x^5$

Practice: Exponent Rule 1 - Product of Powers

On a piece of paper, try the problems below. More practice is provided at the end of the lesson (last slide).

Product of Power

For the following, write each expression in expanded form. Then write the simplified expression in exponential form.

#	Expression	Expanded Form	Exponential Form
1	x^4x^6		
2	$a^3b^2 \cdot a^3b^5$		
3	$(3abc)(2a^2b)$		

For the following, simplify each expression.

4. x^6x^{12}	5. $y^{50}y^{20}$	6. $a^{13}b^5 \cdot a^3b^{20}$	7. $5a^5 \cdot -4ab^6$	8. $3y^2 \cdot 2x^4$

Practice: Exponent Rule 1 - Product of Powers **ANSWERS**

Check your work from the practice. More practice is provided at the end of the lesson (last slide).

Product of Power

For the following, write each expression in expanded form. Then write the simplified expression in exponential form.

#	Expression	Expanded Form	Exponential Form
1	x^4x^6	$x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x$	x^{10}
2	$a^3b^2 \cdot a^3b^5$	$a \cdot a \cdot a \cdot a \cdot a \cdot a \cdot b \cdot b \cdot b \cdot b \cdot b \cdot b \cdot b$	a^6b^7
3	$(3abc)(2a^2b)$	$6 \cdot a \cdot a \cdot a \cdot b \cdot b \cdot c$	$6a^3bc$

For the following, simplify each expression.

4. x^6x^{12} x^{6+12} x^{18}	5. $y^{50}y^{20}$ y^{50+20} y^{70}	6. $a^{13}b^5 \cdot a^3b^{20}$ $a^{13+3} \cdot b^{5+20}$ $a^{16}b^{25}$	7. $5a^5 \cdot -4ab^6$ $-20a^{5+1}b^6$ $-20a^6b^6$	8. $3y^2 \cdot 2x^4$ $6x^4y^2$

Instruction: Exponent Rule 2 - Quotient of Powers

Read through the explanation of the exponent rule: Quotient of Powers, then watch the video.

Quotient of Powers Property video linked here.

Quotient of Powers $\frac{a^m}{a^n} = a^{m-n}$

Bases must be the same.

Bases seen more than once.

SUBTRACT exponents.

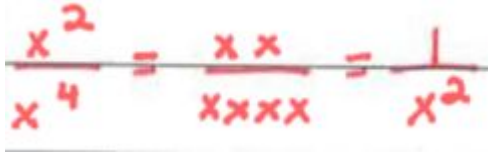
Simplify fractions, if necessary.

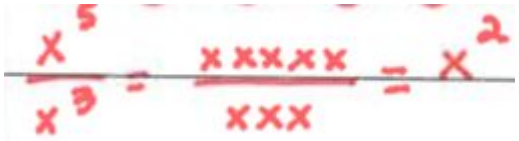
EXAMPLES:

$\frac{x^5}{x^3}$ x^2

$\frac{18c^3}{-3c^2}$ $-6c$

$\frac{3a^3b^5}{9ab^2}$ $\frac{1a^2b^3}{3}$





Practice: Exponent Rule 2 - Quotient of Powers

On a piece of paper, try the problems below. More practice is provided at the end of the lesson (last slide).

Quotient of Powers

For the following, write each expression in expanded form. Then write the simplified expression in exponential form.

#	Expression	Expanded Form	Exponential Form
9	$\frac{4^4}{4^2}$		
10	$\frac{a^8}{a^3}$		
11	$\frac{x^4y^7}{x^3y^3}$		

For the following, simplify each expression.

12. $\frac{b^{20}}{b^5}$	13. $\frac{x^{24}}{x^{16}}$	14. $\frac{x^2y^3}{y^7}$	15. $\frac{p^{10}r^{20}}{p^3p^{10}}$	16. $\frac{5^4a^4b^2}{5^3ab^2}$

Practice: Exponent Rule 2 - Quotient of Powers **ANSWERS**

Check your work from the practice. More practice is provided at the end of the lesson (last slide).

Quotient of Powers

For the following, write each expression in expanded form. Then write the simplified expression in exponential form.

#	Expression	Expanded Form	Exponential Form
9	$\frac{4^4}{4^2}$	$\frac{4\cdot4\cdot4\cdot4}{4\cdot4}$	4^2
10	$\frac{a^8}{a^3}$	$\frac{a\cdot a\cdot a\cdot a\cdot a\cdot a\cdot a\cdot a}{a\cdot a\cdot a}$	a^5
11	$\frac{x^4y^7}{x^3y^3}$	$\frac{x\cdot x\cdot x\cdot x\cdot x\cdot x\cdot x\cdot y\cdot y\cdot y\cdot y}{x\cdot x\cdot x\cdot y\cdot y\cdot y}$	xy^4

For the following, simplify each expression.

12. $\frac{b^{20}}{b^5}$	13. $\frac{x^{24}}{x^{16}}$	14. $\frac{x^2y^3}{y^7}$	15. $\frac{p^{10}r^{20}}{p^3p^{10}}$	16. $\frac{5^4a^4b^2}{5^3ab^2}$
b^{20-5}	x^{24-16}	x^2y^{3-7}	$p^{10-3}r^{20-10}$	$5^{4-3}a^{4-1}b^{2-2}$
b^{15}	x^8	$\frac{x^2}{y^4}$	p^7r^{10}	$5a^3$

Instruction: Exponent Rule 3&4 - Negative & Zero Exponents

Read through the explanation of the exponent rule: Negative and Zero Exponents, then watch the video.

Negative Exponents video linked here.

** Zero Exponents video linked here.**

Negative and Zero Exponents

$$a^{-n} = \frac{1}{a^n} \qquad \frac{1}{a^{-n}} = a^n$$

$$(a \neq 0)$$

All negative exponents must be moved so that it is positive. If in numerator then move to denominator. If in denominator then move to numerator.

$$a^0 = 1 \qquad (a \neq 0)$$

Any power which has an exponent of zero is always one.

EXAMPLES:

x^{-8} → $\frac{1}{x^8}$

$\frac{3}{x^{-6}}$ → $3x^6$

$2x^{-7} \cdot 3x^4$ → $6x^{-3}$ → $\frac{6}{x^3}$

$x^{-3} = \frac{1}{x^3}$

$\frac{1}{x^{-4}} = x^4$

t^0 → 1

3^0 → 1

$x^0 = 1 \quad 3^0 = 1$

Practice: Exponent Rule 3&4 - Negative & Zero Exponents

On a piece of paper, try the problems below. More practice is provided at the end of the lesson (last slide).

Zero Exponent Rule

1) Any non-zero number to the zero power is equivalent to _____ .

For the following, simplify each expression.

2) 4^0	**3)** $(-2)^0$	**4)** $\left(\frac{3}{4}\right)^0$	**5)** 10^0

Negative Exponent

6) Any non-zero number to the negative *n* power is the _____ _____ of its *n*th power.

For the following, simplify each expression. Express each using only positive exponents.

7) 4^{-3}	**8)** 7^{-2}	**9)** $(-3)^{-4}$	**10)** $\frac{1}{5^{-2}}$

Practice: Exponent Rule 3&4 - Negative & Zero Exponents **ANSWERS**

Check your work from the practice. More practice is provided at the end of the lesson (last slide).

Zero Exponent Rule

1) Any non-zero number to the zero power is equivalent to ___1___.

For the following, simplify each expression.

2) 4^0 1	**3)** $(-2)^0$ 1	**4)** $\left(\frac{3}{4}\right)^0$ 1	**5)** 10^0 1

Negative Exponent

6) Any non-zero number to the negative *n* power is the ___multiplicative___ ___inverse___ of its *n*th power.

For the following, simplify each expression. Express each using only positive exponents.

7) 4^{-3} $\frac{1}{4^3}$ or $\frac{1}{64}$	**8)** 7^{-2} $\frac{1}{7^2}$ or $\frac{1}{49}$	**9)** $(-3)^{-4}$ $\frac{1}{(-3)^4}$	**10)** $\frac{1}{5^{-2}}$ 5^2 or 25

Instruction: Exponent Rule 5 - Power Rule

Read through the explanation of the exponent rule: Power Rule, then watch the video.

Power Rule (Power of a Power) video linked here.

Power Rule (Power of a Product) video linked here.

Power Rule

$$(ab)^m = a^m b^m$$

More than one base, but bases only seen once.

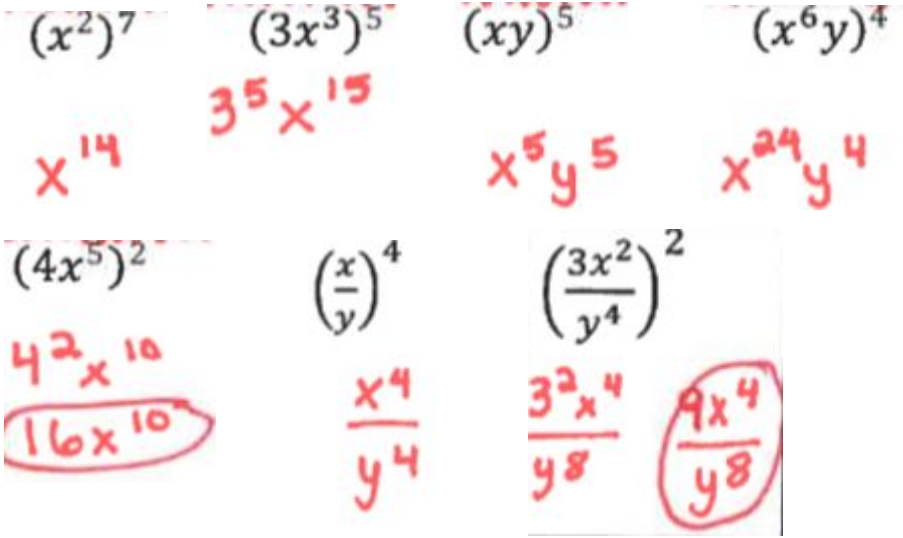
Parenthesis present.

APPLY the exponent to all terms (bases).

$$(a^m)^n = a^{m \cdot n}$$

Two exponents. Multiply exponents.

EXAMPLES:



Practice: Exponent Rule 5 - Power Rule

On a piece of paper, try the problems below. More practice is provided at the end of the lesson (last slide).

1) $(4^3)^5$

2) $(a^6)^4$

3) $(2x^4)^3$

4) $(5a^7b^6)^3$

5) $(2x^2)^3$

6) $(5x^2y^4)^3$

7) $(x^{-4})^{-4}$

8) $\left(\frac{x}{2}\right)^2$

Practice: Exponent Rule 5 - Power Rule **ANSWERS**

Check your work from the practice. More practice is provided at the end of the lesson (last slide).

1) $(4^3)^5$

4^{15}

2) $(a^6)^4$

a^{24}

3) $(2x^4)^3$

$2^3 x^{12}$

$8x^{12}$

4) $(5a^7b^6)^3$

$5^3 a^{21} b^{18}$

$125a^{21}b^{18}$

5) $(2x^2)^3$

$8x^6$

6) $(5x^2y^4)^3$

$125x^6x^{12}$

7) $(x^{-4})^{-4}$

X^{16}

8) $\left(\frac{x}{2}\right)^2$

$\frac{x^2}{4}$

Additional Instruction - Exponent Rules:

Watch the video if needed.

Create your own table to look back on when you are working on exponent problems.

Law	Example
$a^m a^n = a^{m+n}$	$2^3 2^4 = 2^{3+4} = 2^7 = 128$
$(a^m)^n = a^{mn}$	$(2^3)^4 = 2^{3 \cdot 4} = 2^{12} = 4096$
$(ab)^n = a^n b^n$	$(2a)^5 = 2^5 a^5 = 32a^5$
$(\frac{a}{b})^n = \frac{a^n}{b^n}$	$(\frac{2}{5})^3 = \frac{2^3}{5^3} = \frac{8}{125}$
$\frac{a^m}{a^n} = a^{m-n}$	$\frac{2^5}{2^3} = 2^{5-3} = 2^2 = 4$
$\frac{a^m}{a^n} = \frac{1}{a^{n-m}}$	$\frac{2^3}{2^5} = \frac{1}{2^{5-3}} = \frac{1}{2^2} = \frac{1}{4}$

Remember, if you are stuck expand the problem!!!

Example Expanded:

$$3a^3 \cdot 2a^2$$

$$3 \cdot a \cdot a \cdot a \cdot 2 \cdot a \cdot a$$

Additional Practice:

Click on the links below to get additional practice and to check your understanding!

Exponents Rules Pirate Game

Exponents Review Otter Game

Exponents Rags to Riches Review Game