# **Topic 2: Apply Laws of Exponents**

Law	Words	Algebra	Example
Product of Powers			
Quotient of Powers			
Power of a Power			
Power of a Product			
Power of a Quotient			
Negative Exponent			
Identity Exponent			
Zero Exponent			
Scientific No	tation		
Significant D	igits		

# Lesson 1: Use Laws of Integer Exponents Day 1

Goal: Apply the **Laws of Exponents** to integer exponents Evaluate expressions with **integer exponents** 

must be the same.

- 1. Keep the
- 2. \_\_\_\_\_ the exponents and evaluate

**Essential Understanding** You can use a property of exponents to multiply powers with the same base.

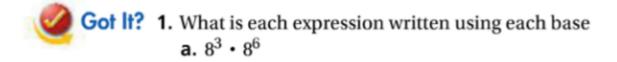
You can write a product of powers with the same base, such as  $3^4 \cdot 3^2$ , using one exponent.



What is each expression written using each base only once?

$$12^4 \cdot 12^3 =$$

$$(-5)^{-2}(-5)^7 =$$



c. 
$$9^{-3} \cdot 9^2 \cdot 9^6$$

When variable factors have more than one base, be careful to combine ONLY those powers with the same base.



What is the simplified form of each expression?

**a.** 
$$5x^4 \cdot x^9 \cdot 3x$$

**b.** 
$$-4c^3 \cdot 7d^2 \cdot 2c^{-2}$$

Work backwards. Using the Multiplication Rule for exponents, rewrite the expressions.

1. 6<sup>7</sup>

2.  $8b^4$ 

3.  $3^5 x^{12}$ 

# Lesson 1: Use Laws of Integer Exponents Day 2

Quotient of Powers Law: \* \_\_\_\_\_ must be the same.

1. Keep the \_\_\_\_\_

2. \_\_\_\_\_ the exponents and evaluate

**Essential Understanding** You can use properties of exponents to divide powers with the same base.

You can use repeated multiplication to simplify quotients of powers with the same base. Expand the numerator and the denominator. Then divide out the common factors.

$$\frac{4^{5}}{4^{3}}$$

take note	Property	Dividing Powers With the Same Base	
Words Algebra			
Examples			



### Problem 1 Dividing Algebraic Expressions

What is the simplified form of each expression?



$$\frac{m^2n^4}{m^5n^3}$$

You can use repeated multiplication to simplify a quotient raised to a power.

$$\left(\frac{x}{y}\right)^3 =$$

Extra examples for class review:

1. 
$$\frac{9^7}{9^4}$$

2. 
$$\frac{4.2^6}{4.2^5}$$

3. 
$$\frac{(-8)^8}{(-8)^4}$$

Work backwards. Use division properties of exponents to find an equivalent expression:

1. 4<sup>3</sup>

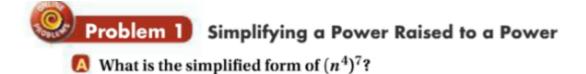
2. 5<sup>6</sup>

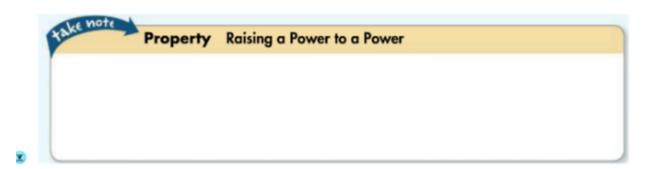
3.  $9d^4$ 

# Lesson 1: Use Laws of Integer Exponents Day 3

Power of a Power Law: \*Raise everything to the

- 1. Keep the \_\_\_\_\_
- 2. the exponents

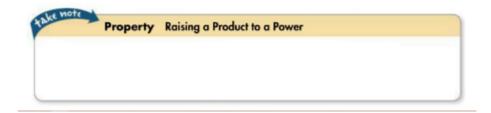






Got It? 1. What is the simplified form of each expression in parts (a)-(d)?  $(p^5)^4$ 

 $(5x^3)^2$ 





What is the simplified form of each expression?  $(7m^9)^3$ 

Work backwards. Use power properties of exponents to find an equivalent expression:

1.  $c^9$ 

2. 48

3.  $5^{10}x^6$ 

Power of a Product Law: \* \_\_\_\_\_ must be the same.

- 1. \_\_\_\_\_ the bases & keep the exponent
- 2. Evaluate the \_\_\_\_\_

4 <sup>-2</sup> · 5 <sup>-2</sup>

 $1.3^{-3} \cdot 0.2^{-3}$ 

 $(-3)^{-1} \cdot 8^{-1}$ 

Power of a Quotient Law: Raise the numerator and denominator to the power individually

or \_\_\_\_\_ first if possible

- 1. \_\_\_\_\_ the bases & keep the exponent
- 2. Evaluate the \_\_\_\_\_

$$\left(\frac{5^9}{5^5}\right)^2$$

$$\left(\frac{x^6}{x^5}\right)^4$$

$$\left(\frac{2^3}{1^9}\right)^2$$

# Lesson 1: Use Laws of Integer Exponents Day 4

The Negative Exponent La	<u>aw</u> : Raising a number to a	of -1 is the

same as finding the \_\_\_\_\_ of that number.

**Essential Understanding** You can extend the idea of exponents to include zero and negative exponents.

Consider  $3^3$ ,  $3^2$ , and  $3^1$ . Decreasing the exponents by 1 is the same as dividing by 3. If you continue the pattern,  $3^0$  equals 1 and  $3^{-1}$  equals  $\frac{1}{3}$ .



#### Properties Zero and Negative Exponents

**Zero as an Exponent** For every nonzero number a,  $a^0 = 1$ .

Examples  $4^0 = 1$   $(-3)^0 = 1$   $(5.14)^0 = 1$ 

**Negative Exponent** For every nonzero number a and integer n,  $a^{-n} = \frac{1}{a^n}$ .

Examples 
$$7^{-3} = \frac{1}{7^3}$$
  $(-5)^{-2} = \frac{1}{(-5)^2}$ 

Why can't you use 0 as a base with zero exponents? The first property on the previous page implies the following pattern.

$$3^0 = 1$$
  $2^0 = 1$ 

$$1^0 = 1$$

$$0^0 = 1$$

However, consider the following pattern.

$$0^3 = 0$$

$$0^2 = 0$$

$$0^1 = 0$$
  $0^0 = 0$ 

It is not possible for  $0^0$  to equal both 1 and 0. Therefore  $0^0$  is undefined.

Why can't you use 0 as a base with a negative exponent? Using 0 as a base with a negative exponent will result in division by zero, which is undefined.







What is the simplified form of each expression?





What is the simplified form of each expression?

**a.** 
$$4^{-3}$$

**b.** 
$$(-5)^0$$

**c.** 
$$(-4)^{-2}$$

# Problem 2 Simplifying Exponential Expressions

What is the simplified form of each expression?

$$\triangle 5a^3b^{-2}$$

$$\mathbb{B}\frac{1}{r^{-5}}$$



Got It? 2. What is the simplified form of each expression?

- **a.**  $x^{-9}$
- **b.**  $\frac{1}{n^{-3}}$
- **c.**  $4c^{-3}b$

**d.** 
$$\frac{2}{a^{-3}}$$

Extra Class Examples:

$$(\frac{1}{2})^{-1}$$

$$4^{-5}$$

$$\mathrm{m}^{-9}$$

The Zero Exponent Law: Raising a number to a power of zero always equals \_\_\_\_\_.

Use the laws to evaluate:

$$(2.38^{-5})^0 + \left[ \left( \frac{604}{729} \right)^{-1} \right]^{-1} + \frac{9^{-3}}{5^{-3}}$$

Work backwards. Use of exponents all the Laws of Exponents find equivalent expressions:

1. Select all the expressions equivalent to  $9b^2$ .

a. 
$$1/3^{-2}b^{-2}$$

d. 
$$3^4b^4/3^2b^2$$

### **Lesson 3: Understand Scientific Notation**

Goal: Use **scientific notation** to write very large or small numbers.

Convert numbers written in scientific notation into **standard form**.

Did you know....?

## Key Concept

## **Scientific Notation**

Words Scientific notation is when a number is written as the

product of a factor and an integer power of 10. The factor must be greater than or equal to 1 and less than 10.

**Symbols**  $a \times 10^n$ , where  $1 \le a < 10$  and n is an integer

**Example**  $425,000,000 = 4.25 \times 10^8$ 



3

#### **Powers of Ten**

multiplying a factor by a positive power of 10 moves the decimal point right. multiplying a factor by a negative power of 10 moves the decimal point left.

### Complete the table below.

Expression	Product	Expression	Product	
$4.7 \times 10^{1} = 4.7 \times 10^{1}$	47	$4.7 \times 10^{-1} = 4.7 \times \frac{1}{10}$	0.47	
$4.7 \times 10^2 = 4.7 \times 100$		$4.7 \times 10^{-2} = 4.7 \times \frac{1}{100}$	Ž.	/
$4.7 \times 10^3 = 4.7 \times 1,000$		$4.7 \times 10^{-3} = 4.7 \times \frac{1}{1000}$		
4.7 × 10 <sup>4</sup> = 4.7 ×		4.7 × 10 <sup>-4</sup> = 4.7 ×		

## **Examples**

Write each number in standard form.

**1.** 
$$5.34 \times 10^4$$

**2.** 
$$3.27 \times 10^{-3}$$

## **Examples**

Write each number in scientific notation.

**3.** 3,725,000

4. 0.000316

## Example: comparing and ordering with scientific notation

Refer to the table at the right.
 Order the countries according to the amount of money visitors spent in the United States from greatest to least.



Group the numbers by their power of 10.



Order the decimals.

Dollars Spent by International Visitors in the U.S				
Country Dollars Spent				
Canada	$1.03 \times 10^{7}$			
India	1.83 × 10 <sup>6</sup>			
Mexico	$7.15 \times 10^{6}$			
United Kingdom	$1.06 \times 10^{7}$			

#### Extra In Class Notes:

When using calculators to represent very large and very small numbers with an exponent indicated as "E", instruction relates the number following "E" as the power of 10.

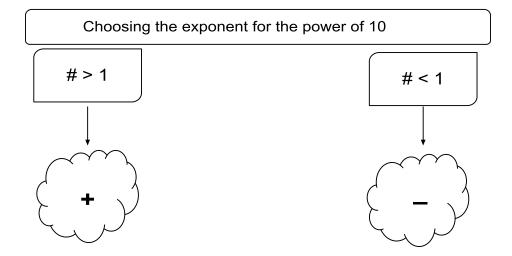
Ex.

Roderick is comparing two numbers shown in scientific notation on his calculator. The first number was displayed as 2.3147E27 and the second number was displayed as 3.5982E - 5.

What are these 2 numbers on the calculator written in scientific notation?

0	
· · · · · · · · · · · · · · · · · · ·	

Numbers written in Scientific Notation are written as a	1	of	factors.



Scientific Notation involves moving the \_\_\_\_\_ not counting zeros or digits.

#### **Practice Examples:**

Write the numbers in Standard Form

$$2.65 \cdot 10^{-7}$$
  $1.03 \cdot 10^{-8}$ 

Write the numbers in Scientific Notation

Order the number of visitors from least to greatest

U.S. City	Number of Visitors
-	$7.21 \times 10^{5}$
Boston	
Las Vegas	1.3 × 10 <sup>6</sup>
Los Angeles	2.2 × 10 <sup>6</sup> Grade 8:
Metro D.C. area	9.01 × 10 <sup>5</sup>

Which number or numbers are NOT written correctly in Scientific Notation?

 $1.036 \cdot 10^{6}$   $0.45 \cdot 10^{-7}$   $5.60 \cdot 10^{2}$ 

Significant digits: \_\_\_\_\_ digits of a number and any zeros in between them (zeros at the end of a number can be significant if they are used for a precise measurement)

thousands	hundreds	tens	ones		tenths	hundredths	thousandths
$10^{3}$	$10^{2}$	$10^{1}$	$10^{0}$	-	10-1	$10^{-2}$	$10^{-3}$
3	2	4	0		0	0	0
			0		3	2	4

### Lesson 4: Operations with Numbers in Scientific Notation

Goal: apply number properties to calculations with numbers in scientific notation

Operations with Scientific Notation: use "LARS"

LARS stands for "Left Add, Right Subtract"

#### Addition:

- Make the powers of 10 \_\_\_\_\_\_.
- Add the \_\_\_\_\_\_.
- Keep the powers of \_\_\_\_\_ the \_\_\_\_\_.
- Put the answer in \_\_\_\_\_

### Try These:

#### Subtracting:

- Make the powers of 10 \_\_\_\_\_\_.
- Subtract the \_\_\_\_\_\_.
- 3) Keep the powers of \_\_\_\_\_ the \_\_\_\_\_.
- Put the answer in \_\_\_\_\_

### Try These:

Multiplying:

1) Multiply the \_\_\_\_\_

Multiply the <u>powers of 10</u>

(Remember the rule for multiplying with exponents: keep the \_\_\_\_\_ and add the \_\_\_\_\_.)

4) Put the answer in \_\_\_\_\_

Try These:

5 2 × 10/2//

4

A)  $(8.5 \times 10^4)(5.12 \times 10^3)$  B)  $(5.2 \times 10^2)(6 \times 10^5)$ 

Dividing:

1) Divide the \_\_\_\_\_.

2) Divide the \_\_\_\_\_\_.

(Remember the rule for dividing with exponents:

keep the \_\_\_\_\_ and subtract the \_\_\_\_\_\_.)

Put the answer in \_\_\_\_\_\_\_.

Try These:

$$(3.2 \cdot 10^3) + (3.8 \cdot 10^5)$$

$$(4.5 \cdot 10^5) - (1.2 \cdot 10^4)$$

### **Lesson 6: Multiply Linear Expressions**

To	a sum by a number- multiply each	
-		

Example:  $2(7 + 4) = 2 \times 7 + 2 \times 4$ 

$$a (b + c) = ab + ac$$

### Use the Distributive Property to Rewrite Expressions

by the number \_\_\_\_\_\_.

$$2a(a + 4)$$

$$3b(13 + b)$$

$$-3z(10z + 14)$$

$$(f + 2)(-6.2f)$$

### Lesson 7: Factor Algebraic Expressions

: a number, a variable, or a together. (there is no + or - in a monomial)	number and variable multiplied
To factor a number means: write it as a	of its factors.
Identify the GCF by writing out the factors of a nu	mber and variable
12	25x
28c	15xy
42 mn	18a
14mn	20ab
To Factor an Expression:  1. Identify the GCF (use upside down division 2. Write it outside of a ( )  3. Divide each term by the GCF and write that	•
14x + 7y	4x - 28
6x + 35	3x + 33y