By the end of the lesson, we will be able to:

- Simplify exponential equations using the product rule, the quotient rule, the power rule, and the Law of Exponents.
- Evaluate Exponential expressions with a Zero or Negative exponent.
- Convert between Scientific Notation and Decimal Notation.
- Use Scientific Notation to multiply and divide.

**NOTATION:** in the expression $a^n$ a is called the ***base***, and n is called the ***exponent or power***.

Let's look at the rules for combining exponents.

**Multiplying** - add exponents. If there are numerical coefficients, you multiply them, then deal with the variables.

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

A) $3^2 \cdot 3^3 \quad =$

B) $2z^2 \cdot 5z^4 \ =$

**Dividing** - subtract exponents If there are numerical coefficients, you divide or reduce the fraction before you deal with the variables.

$$\frac{a^m}{a^n} = a^{m-n}$$

C) $\frac{6^4}{6} =$

D) $\frac{25m^8}{15m^3} =$

**Zero Exponents** - any number or variable that has a zero exponent is always equal to 1

$$\frac{a^m}{a^m} = a^0 = 1$$

E) $\mathbf{5^0} =$

F) $\mathbf{18x^0} =$

**Negative exponents** - moving the exponential factor to the denominator creates a positive exponent.

$$a^{-n} = \frac{1}{a^n} \quad or \quad \frac{1}{a^{-n}} = a^n$$

H) $\mathbf{5b^{-4}} =$

I) $\mathbf{\frac{5}{3}z^{-3} \cdot \left(-\frac{9}{20}z^4\right)} =$

## Power to a power - multiply exponents

$$(a^m)^n = a^{mn}$$

J) $\left(\mathbf{3}^2\right)^{\mathbf{4}} =$

K) $\left(\mathbf{7}^2\right)^{\mathbf{0}} =$

**Power of a product** - exponent applies to each factor (like distributing).

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

L) $(\mathbf{2}\boldsymbol{a})^{\mathbf{4}} =$

M) $(-\mathbf{4}\boldsymbol{b}^{\mathbf{3}})^{-\mathbf{2}} =$

**Power of a quotient** - exponent applies to numerator and denominator.

$$\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$$

N) $\left(\frac{z}{5}\right)^3 =$

O) $\left(\frac{5b^3}{c^2}\right)^2 =$

**Power of a negative quotient** - exponent applies to numerator and denominator (like distributing) This will cause everything inside to switch places.

$$\left(\frac{a}{b}\right)^{-n} = \frac{a^{-n}}{b^{-n}} = \frac{b^n}{a^n}$$

P) $\left(\frac{x}{2}\right)^{-3} =$

***SCIENTIFIC NOTATION.*** A number is written in scientific notation when it is in the form

$a \times 10^n$ where $1 \leq |a| \leq 10$

and $n$ is an integer.

## *To change a decimal to scientific notation:*

**Step 1:** Count the number N of decimal places that the decimal point must be moved in order to get only one digit (a) in front of the decimal.

**Step 2:** If you had to move the decimal to the left (you started with a large number with several value places before the decimal), then your exponent is positive $\left(a \times 10^N\right)$. If you had to move the decimal to the right (you started with a decimal that had only 0 in front of it), then your exponent will be negative $(a \times 10^{-N})$.

**EXAMPLES:** Write the following in scientific notation.

Q) $\mathbf{238,400 =}$

R) $\mathbf{0.071 =}$

## *REVERSING THE PROCESS (going from scientific notation to decimal notation):*

Look at the exponent on the 10. If the ***exponent is negative***, move the decimal N spaces to the ***left*** (toward the negative end of the number line). If the ***exponent is positive***, move the decimal N spaces to the ***right*** (toward the positive end of the number line).

**EXAMPLES:** Write the following in decimal notation.

S) $-\mathbf{2.8} \times \mathbf{10^4} =$

T) $\mathbf{1.49} \times \mathbf{10^{-5}} =$

# *MULTIPLYING & DIVIDING WITH SCIENTIFIC NOTATION.*

Follow the usual rules of exponents, except separate the pieces. Simplify the numbers, then add/subtract the exponents on the 10's.

***EXAMPLES:***

U) $(3 \times 10^2)(2 \times 10^4) =$

V) $(3.2 \times 10^{-3})(4.8 \times 10^{-4}) =$

## ***EXAMPLES:***

W) $\dfrac{2.8\times10^{9}}{1.4\times10^{4}} =$

X) $\dfrac{3.6\times10^{3}}{7.2\times10^{-1}} =$

## Homework:

*Pg. 351:* # 19-24, 31, 33, 37, 41, 45, 51, 57, 65, 69, 71, 81, 83, 85, 87, 91, 101, 105, 115, 117, 121, 131.