

Warm Up:

Simplify the following for $x = 3$ and $y = -2$

$$3xy + 2x + 6y$$

$$-2y - 4x + 5y$$

$$3 \cdot 3 \cdot -2 + 2 \cdot 3 + 6 \cdot -2$$
$$-24$$

$$-18$$

1-5 Properties of Exponents

Objectives

Simplify expressions involving exponents.

Use scientific notation.

1-5 Properties of Exponents

In an expression of the form a^n , a is the base, n is the exponent, and the quantity a^n is called a power. The exponent indicates the number of times that the base is used as a factor.

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

Base Exponent

$$a^n = \underbrace{a \cdot a \cdot a \cdot \dots \cdot a \cdot a \cdot a}_{a \text{ is a factor } n \text{ times}}$$

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1-5 Properties of Exponents

When the base includes more than one symbol, it is written in parentheses.

Exponential Form	Base	Expanded Form
$-2x^3$	x	$-2(x \cdot x \cdot x)$
$-(2x)^3$	$2x$	$-(2x)(2x)(2x)$
$(-2x)^3$	$-2x$	$(-2x)(-2x)(-2x)$

Reading Math

A **power** includes a base and an exponent. The expression 2^3 is a power of 2. It is read "2 to the third power" or "2 cubed."

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1-5 Properties of Exponents**Example 1A: Writing Exponential Expressions in Expanded Form**

Write the expression in expanded form.

$$(5z)^2$$

$$5z \cdot 5z$$

1-5 Properties of Exponents**Example 1B: Writing Exponential Expressions in Expanded Form**

Write the expression in expanded form.

$$-s^4$$

$$-s \cdot s \cdot s \cdot s$$

1-5 Properties of Exponents**Example 1C: Writing Exponential Expressions in Expanded Form**

Write the expression in expanded form.

$$3h^3(k + 3)^2$$

$$3 \cdot h \cdot h \cdot h (k + 3)(k + 3)$$

1-5 Properties of Exponents**Check It Out! Example 1a**

Write the expression in expanded form.

$$(2a)^5$$

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

1-5 Properties of Exponents**Check It Out!** Example 1b

Write the expression in expanded form.

$$3b^4$$

1-5 Properties of Exponents**Check It Out!** Example 1c

Write the expression in expanded form.

$$-(2x - 1)^3y^2$$

Now we will explore some properties of exponents and discover what those properties are

$$x^2 \cdot x^3 = x \cdot x \cdot x \cdot x \cdot x = x^5$$

$$\frac{x^4}{x} = \frac{\cancel{x} \cdot \cancel{x} \cdot \cancel{x} \cdot \cancel{x}}{\cancel{x}} = x^3$$

1-5 Properties of Exponents

Zero and Negative Exponents

For all nonzero real numbers a and integers n ,

WORDS	NUMBERS	ALGEBRA
Zero Exponent Property A nonzero quantity raised to the zero power is equal to 1.	$100^0 = 1$	$a^0 = 1$
Negative Exponent Property A nonzero base raised to a negative exponent is equal to the reciprocal of the base raised to the opposite, positive exponent.	$7^{-2} = \left(\frac{1}{7}\right)^2 = \frac{1}{7^2}$ $\left(\frac{3}{2}\right)^{-4} = \left(\frac{2}{3}\right)^4$	$a^{-n} = \left(\frac{1}{a}\right)^n = \frac{1}{a^n}$ $\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$

1-5 Properties of Exponents**Example 2A: Simplifying Expressions with Negative Exponents**

Simplify the expression.

$$3^{-2}$$
$$\frac{1}{3^2} = \frac{1}{9}$$

1-5 Properties of Exponents**Example 2B: Simplifying Expressions with Negative Exponents**

Simplify the expression.

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

1-5 Properties of Exponents**Check It Out!** Example 2a

Simplify the expression.

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

$$\frac{3^2}{1} = 9$$

1-5 Properties of Exponents**Check It Out!** Example 2b

Write the expression in expanded form.

$$(-5)^{-5}$$

1-5 Properties of Exponents

Properties of Exponents

For all nonzero real numbers a and b and integers m and n ,

WORDS	NUMBERS	ALGEBRA
Product of Powers Property To multiply powers with the same base, add the exponents.	$4^3 \cdot 4^2 = 4^{3+2} = 4^5$	$a^m \cdot a^n = a^{m+n}$
Quotient of Powers Property To divide powers with the same base, subtract the exponents.	$\frac{3^7}{3^2} = 3^{7-2} = 3^5$	$\frac{a^m}{a^n} = a^{m-n}$
Power of a Power Property To raise one power to another, multiply the exponents.	$(4^3)^2 = 4^{3 \cdot 2} = 4^6$	$(a^m)^n = a^{m \cdot n}$
Power of a Product Property To find the power of a product, apply the exponent to each factor.	$(3 \cdot 4)^2 = 3^2 \cdot 4^2$	$(ab)^m = a^m b^m$
Power of a Quotient Property To find the power of a quotient, apply the exponent to the numerator and denominator.	$\left(\frac{3}{5}\right)^2 = \frac{3^2}{5^2}$	$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$

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1-5 Properties of Exponents

Example 3A: Using Properties of Exponents to Simplify Expressions

Simplify the expression. Assume all variables are nonzero.

$$3z^7(-4z^2)$$

$$-12z^7z^2$$

$$-12z^9$$

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1-5 Properties of Exponents

Example 3B: Using Properties of Exponents to Simplify Expressions

Simplify the expression. Assume all variables are nonzero.

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

$$(yz^{-2})^3$$

$$\left(\frac{y^{-3}}{z^2}\right)^3$$

$$\frac{y^3}{(z^2)^3}$$

$$\frac{y^3}{z^6}$$

1-5 Properties of Exponents

Check It Out! Example 3a

Simplify the expression. Assume all variables are nonzero.

$$(5x^6)^3$$

$$5^3(x^6)^3$$

$$125x^{18}$$

1-5 Properties of Exponents

Check It Out! Example 3b

Simplify the expression. Assume all variables are nonzero.

$$(-2a^3b)^{-3}$$

$$(-2)^{-3} (a^3)^{-3} b^{-3}$$

$$\frac{1}{(-2)^3} \cdot \frac{1}{(a^3)^3} \cdot \frac{1}{b^3}$$

$$\frac{1}{-8} \cdot \frac{1}{a^9} \cdot \frac{1}{b^3}$$

Partner challenge: write 3 expressions that can be simplified (try to stump them) then see if they can do it...

1-5 Properties of Exponents

Scientific notation is a method of writing numbers by using powers of 10. In scientific notation, a number takes a form $m \times 10^n$, where $1 \leq m < 10$ and n is an integer.

Scientific Notation	Move the decimal	Standard Notation
1.275×10^7	Right 7 places	12,750,000 <small>~~~~~</small>
3.5×10^{-7}	Left 7 places	0.00000035 <small>~~~~~</small>

You can use the properties of exponents to calculate with numbers expressed in scientific notation.

1-5 Properties of Exponents

Example 4A: Simplifying Expressions Involving Scientific Notation

Simplify the expression. Write the answer in scientific notation.

$$\frac{4.5 \times 10^{-5}}{1.5 \times 10^6}$$

$$\frac{4.5}{1.5} \quad \frac{10^{-5}}{10^6}$$

$$3.0 \times 10^{-11}$$

1-5 Properties of Exponents

Example 4B: Simplifying Expressions Involving Scientific Notation

Simplify the expression. Write the answer in scientific notation.

$$(2.6 \times 10^4)(8.5 \times 10^7)$$

$$\begin{aligned} & 2.6 \cdot 8.5 \quad 10^4 \cdot 10^7 \\ & 22.1 \times 10^{11} \\ & 2.21 \times 10^{12} \end{aligned}$$

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1-5 Properties of Exponents

Check It Out! Example 4a

Simplify the expression. Write the answer in scientific notation.

$$\frac{2.325 \times 10^6}{9.3 \times 10^9}$$

$$\begin{aligned} & 25 \times 10^{-3} \\ & 2.5 \times 10^{-2} \end{aligned}$$

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1-6 Relations and Functions***Objectives***

Identify the domain and range of relations and functions.

Determine whether a relation is a function.

1-6 Relations and Functions***Vocabulary***

relation
domain
range
function

1-6 Relations and Functions

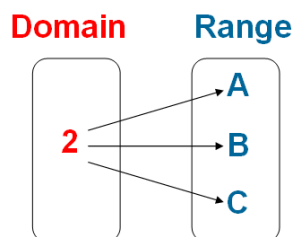
A **relation** is a pairing of input values with output values. It can be shown as a set of ordered pairs (x,y) , where x is an input and y is an output.

The set of input values for a relation is called the **domain**, and the set of output values is called the **range**.

x
 y

1-6 Relations and Functions

Mapping Diagram



Set of Ordered Pairs

$\{(2, A), (2, B), (2, C)\}$

$(x, y) \longrightarrow (\text{input, output}) \longrightarrow (\text{domain, range})$

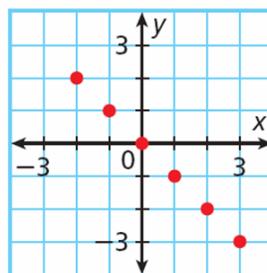
1-6 Relations and Functions**Example 1: Identifying Domain and Range**

Give the domain and range for this relation:

{(100,5), (120,5), (140,6), (160,6), (180,12)}.

1-6 Relations and Functions**Check It Out! Example 1**

Give the domain and range for the relation shown in the graph.



Homework
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