

Exponential Notation

If a is any real number and n is a positive integer, then the n th power of a is

$$a^n = \underbrace{a \cdot a \cdot \dots \cdot a}_{n \text{ factors}}$$

The number a is called the base, and n is called the exponent.

Zero and Negative Exponents

If $a \neq 0$ is a real number and n is a positive integer, then

$$a^0 = 1, \quad a^{-n} = \frac{1}{a^n}$$

Law of Exponent

- $a^m a^n = a^{m+n}$
- $\frac{a^m}{a^n} = a^{m-n}$
- $(a^m)^n = a^{mn}$
- $(ab)^n = a^n b^n$
- $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$
- $\left(\frac{a}{b}\right)^{-n} = \left(\frac{b}{a}\right)^n$
- $\frac{a^{-n}}{b^{-m}} = \frac{b^m}{a^n}$



Example 1:

Eliminate negative exponents and simplify each expression.

(a) $\frac{6st^{-4}}{2s^{-2}t^2}$

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

• $a^m a^n = a^{m+n}$

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• $(a^m)^n = a^{mn}$

• $(ab)^n = a^n b^n$

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

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

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

Example 2: We can write the product $5 \cdot 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5$ as using exponential notation.

Example 3: Evaluate each expression.

• -2^6

• $(-2)^6$

• $\left(\frac{1}{5}\right)^2 \cdot (-3)^3$



Example 4: Evaluate each expression.

$$\bullet \left(\frac{5}{3}\right)^0 \cdot 2^{-1}$$

$$\bullet -2^{-3} \cdot (-2)^0$$

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

$$\bullet 5^3 \cdot 5$$

$$\bullet 3^2 \cdot 3^0$$

$$\bullet (2^2)^3$$

$$\bullet \frac{10^7}{10^4}$$

Example 5: Simplify each expression.

$$\bullet x^2 x^3$$

$$\bullet (-x^2)^3$$

$$\bullet t^{-3} t^5$$

$$\bullet w^{-2} w^{-4} w^5$$

$$\bullet \frac{y^{10} y^0}{y^7}$$

$$\bullet (2x)^2 (5x^6)$$

$$\bullet (2a^3 a^2)^4$$





Simplify each expression and eliminate any negative exponent(s).

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

- $(9y^{-2}z^2)(3y^3z)$

- $(8x^7y^2)\left(\frac{1}{2}x^3y\right)^{-2}$

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

- $\frac{3x^{-2}y^5}{9x^{-3}y^2}$

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

- $\frac{\frac{1}{2}a^{-3}b^{-4}}{2a^{-5}b^{-1}}$

- $\left(\frac{q^{-1}r^{-1}s^{-2}}{r^{-5}sq^{-8}}\right)^{-1}$

- $\left(\frac{xy^{-2}z^{-3}}{x^2y^3z^{-4}}\right)^{-3}$



Scientific Notation

A positive number x is said to be written in *scientific notation* if it is expressed as follows:

$$x = a \times 10^n \quad \text{where } 1 \leq a < 10 \text{ and } n \text{ is an integer}$$

$$3 \times 10^9 = 3,000,000,000$$

$$1.2 \times 10^{-8} = 0.000000012$$

Example 1:

Write each number in scientific notation.

(a) 56920

(b) 0.000093

Example 2:

Write each number in scientific notation.

• 69,300,000

• 7,200,000,000,000

• 0.000028536

• 0.0001213



Example 3:

Write each number in decimal notation.

- 3.19×10^5

- 2.670×10^{-8}

- 7.1×10^{14}

- 8.55×10^{-3}

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