



# Zero and Negative Exponents

CA Standards  
NS 1.2  
NS 2.1  
AF 2.1

**Goal:** Simplify expressions with negative exponents.

## Definition of Zero and Negative Exponents

Let  $a$  be a nonzero number, and let  $n$  be an integer.

### Words

$a$  to the zero power is  $1$ .

$a^{-n}$  is the reciprocal of  $a^n$ .

$a^n$  is the reciprocal of  $a^{-n}$ .

### Algebra

$$a^0 = 1$$

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

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

### Example

$$4^0 = 1$$

$$6^{-4} = \frac{1}{6^4}$$

$$8^3 = \frac{1}{8^{-3}}$$

## EXAMPLE 1 Using Zero and Negative Exponents

a.  $4^0 = 1$

Definition of zero exponent

b.  $2^{-5} = \frac{1}{2^5}$

Definition of negative exponent

$$= \frac{1}{32}$$

Evaluate power.

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

Definition of negative exponent

$$= \frac{1}{\left(\frac{1}{9}\right)}$$

Evaluate power.

$$= 9$$

Divide.

**EXAMPLE 2** Using a Negative Exponent

**Computers** The speed of a computer chip is measured in nanoseconds. One nanosecond is  $\frac{1}{1,000,000,000}$  second. Write one nanosecond in seconds as a power of ten.

**Solution**

$$\begin{aligned} \frac{1}{1,000,000,000} &= \frac{1}{10^9} && \text{Write 1,000,000,000 as } 10^9. \\ &= 10^{-9} && \text{Definition of negative exponent} \end{aligned}$$

**Answer:** One nanosecond is  $10^{-9}$  second.

**EXAMPLE 3** Evaluating an Algebraic Expression

Evaluate the expression  $x^4 \cdot x^{-7}$  when  $x = 6$ .

$$\begin{aligned} x^4 \cdot x^{-7} &= 6^4 \cdot 6^{-7} = 6^{4+(-7)} \\ &= 6^{-3} \\ &= \frac{1}{6^3} = \frac{1}{216} \end{aligned}$$

**Guided Practice** Evaluate the expression.

1. $5^{-5}$	2. $(-3)^{-3}$	3. $8^0$
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Evaluate the expression when  $x = 3$ .

4. $x^{-4}$	5. $x^0$	6. $4^{-x}$
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**EXAMPLE 4** Simplifying Algebraic Expressions**WATCH OUT!**

In an expression such as  $-9x^0$  or  $-3a^{-4}$ , the exponent is applied only to the variable, not to the coefficient.

$$\begin{aligned} \text{a. } -9x^0 &= -9 \cdot x^0 && \text{Zero exponent applies only to } x. \\ &= -9 \cdot 1 && \text{Definition of zero exponent} \\ &= -9 && \text{Multiply.} \end{aligned}$$

$$\begin{aligned} \text{b. } -3a^{-4} &= -3 \cdot a^{-4} && \text{Exponent applies only to } a. \\ &= -3 \cdot \frac{1}{a^4} && \text{Definition of negative exponent} \\ &= \frac{-3}{a^4} && \text{Multiply.} \end{aligned}$$

$$\begin{aligned} \text{c. } \frac{10t^{-3}}{t^2} &= \frac{10 \cdot t^{-3}}{t^2} && \text{Exponent applies only to } t. \\ &= 10 \cdot t^{-3-2} && \text{Quotient of powers property} \\ &= 10 \cdot t^{-5} && \text{Simplify.} \\ &= \frac{10}{t^5} && \text{Definition of negative exponent} \end{aligned}$$

**Homework****Guided Practice** Simplify the algebraic expression.

7.  $5y^{-3}$

8.  $n^{-11} \cdot n^{-5}$

9.  $\frac{8p^2}{p^{-4}}$

10.  $\frac{15x}{3x^{10}}$