

## Key Concept

## Zero and Negative Exponents

### Work Zone

### Negative Exponents

Remember that  $6^{-3}$  is equal to  $\frac{1}{6^3}$ , not  $-216$  or  $-18$ .

Show your work.

a.  $\frac{1}{7^2}$

b.  $\frac{1}{5^4}$

c.  $1$

d.  $\frac{1}{m^3}$

e.  $8^{-3}$

f.  $2^{-2}$

g.  $c^{-5}$

h.  $3^{-3}$

**Words** Any nonzero number to the zero power is **1**. Any nonzero number to the negative  $n$  power is the multiplicative inverse of its  $n$ th power.

**Examples** **Numbers**

$$5^0 = 1$$

$$7^{-3} = \frac{1}{7} \cdot \frac{1}{7} \cdot \frac{1}{7} \text{ or } \frac{1}{7^3}$$

**Algebra**

$$x^0 = 1, x \neq 0$$

$$x^{-n} = \frac{1}{x^n}, x \neq 0$$

$$7^3 = \frac{7^3}{1}$$

inverse of  $7^3$

You can use exponents to represent very small numbers. Negative powers are the result of repeated division.

### Examples

Tutor

Write each expression using a positive exponent.

1.  $6^{-3}$

$$6^{-3} = \frac{1}{6^3} \quad \text{Definition of negative exponent}$$

2.  $a^{-5}$

$$a^{-5} = \frac{1}{a^5} \quad \text{Definition of negative exponent}$$

**Got It?** Do these problems to find out.

a.  $7^{-2}$

b.  $b^{-4}$

c.  $5^0$

d.  $m^{-3}$

### Examples

Tutor

Write each fraction as an expression using a negative exponent other than  $-1$ .

3.  $\frac{1}{5^2}$

$$\frac{1}{5^2} = 5^{-2} \quad \text{Definition of negative exponent}$$

4.  $\frac{1}{36}$

$$\frac{1}{36} = \frac{1}{6^2} \quad \text{Definition of exponent}$$

$$= 6^{-2} \quad \text{Definition of negative exponent}$$

**Got It?** Do these problems to find out.

e.  $\frac{1}{8^3}$

f.  $\frac{1}{4} = \frac{1}{2^2}$

g.  $\frac{1}{c^5}$

h.  $\frac{1}{27} = \frac{1}{3^3}$



## Example



5. **STEM** One human hair is about 0.001 inch in diameter. Write the decimal as a power of 10.

$$\begin{aligned} 0.001 &= \frac{1}{1,000} && \text{Write the decimal as a fraction.} \\ &= \frac{1}{10^3} && 1,000 = 10^3 \\ &= 10^{-3} && \text{Definition of negative exponent} \end{aligned}$$

A human hair is  $10^{-3}$  inch thick.

**Got It?** Do this problem to find out.

- i. **STEM** A water molecule is about 0.0000000001 meter long. Write the decimal as a power of 10.

## STOP and Reflect

Explain below the difference between the expressions  $(-4)^2$  and  $4^{-2}$ .

i.  $\frac{1}{10^{10}} = 10^{-10}$

## Multiply and Divide with Negative Exponents

The Product of Powers and the Quotient of Powers rules can be used to multiply and divide powers with negative exponents.



## Examples



Simplify each expression.

6.  $5^3 \cdot 5^{-5}$

$$\begin{aligned} 5^3 \cdot 5^{-5} &= 5^{3 + (-5)} && \text{Product of Powers} \\ &= 5^{-2} && \text{Simplify.} \\ &= \frac{1}{5^2} \text{ or } \frac{1}{25} && \text{Write using positive exponents. Simplify.} \end{aligned}$$

7.  $\frac{w^{-1}}{w^{-4}}$

$$\begin{aligned} \frac{w^{-1}}{w^{-4}} &= w^{-1 - (-4)} && \text{Quotient of Powers} \\ &= w^{(-1) + 4} \text{ or } w^3 && \text{Subtract the exponents.} \end{aligned}$$

**Got It?** Do these problems to find out.

j.  $3^{-8} \cdot 3^2 = 3^{-6}$

l.  $n^9 \cdot n^{-4} = n^5$

k.  $\frac{11^2}{11^4}$

m.  $\frac{b^{-4}}{b^{-7}}$

$$\begin{aligned} 11^{2-4} &= 11^{-2} \\ b^{-4 - (-7)} &= b^{-4+7} \end{aligned}$$

Show your work.

j.  $\frac{1}{3^6}$

k.  $\frac{1}{11^2} = \frac{1}{121}$

l.  $\frac{n^5}{b^3}$

m.