

# Properties of Exponents

Product of Powers	Power of a Product	Power of a Power	
$a^m \cdot a^n = a^{m+n}$ Add exponents.	$(ab)^m = a^m b^m$ Find the power of each factor.	$(a^m)^n = a^{mn}$ Multiply exponents.	
Quotient of Powers	Power of a Quotient	Negative Exponent	Zero Exponent
$\frac{a^m}{a^n} = a^{m-n}, a \neq 0$ Subtract exponents.	$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}, b \neq 0$ Find the power of the numerator and the power of the denominator.	$a^{-n} = \frac{1}{a^n}, a \neq 0$	$a^0 = 1, a \neq 0$

**Example 1** Evaluate (a)  $4 \cdot 9^0$  and (b)  $(-3)^{-4}$ .

a.  $4 \cdot 9^0 = 1$     Definition of zero exponent

b.  $(-3)^{-4} = \frac{1}{(-3)^4}$     Definition of negative exponent  
 $= \frac{1}{81}$     Evaluate power.

**Example 2** Simplify each expression. Write your answer using only positive exponents.

a.  $2^3 \cdot 2^4 = 2^7 = 128$

b.  $\frac{5^9}{5^6} = 5^{9-6} = 5^3 = 125$

c.  $\frac{12y^0}{x^{-7}} = 12y^0 x^7 = 12x^7$

d.  $\frac{x^6 \cdot x^2}{x^5} = \frac{x^{6+2}}{x^5} = x^{8-5} = x^3$

e.  $(z^4)^2 = z^{4 \cdot 2} = z^8$

f.  $(6mn)^3 = 6^3 \cdot m^3 \cdot n^3 = 216m^3 n^3$

g.  $\left(\frac{y}{3}\right)^4 = \frac{y^4}{3^4} = \frac{y^4}{81}$

h.  $\frac{10x^6 y^{-2}}{5x^3 y} = \frac{10}{5} x^{(6-3)} y^{(-2-1)} = 2x^3 y^{-3} = \frac{2x^3}{y^3}$

## Practice

Check your answers at [BigIdeasMath.com](http://BigIdeasMath.com).

Evaluate the expression.

1.  $(-9)^0$     1

2.  $-8^{-1}$      $-\frac{1}{8}$

3.  $4^{-3}$      $\frac{1}{64}$

4.  $\frac{-5^0}{3^{-2}}$      $-9$

Simplify the expression. Write your answer using only positive exponents.

5.  $2^9 \cdot 2^{-6}$     8

6.  $\frac{10^8}{10^{12}}$      $\frac{1}{10,000}$

7.  $y \cdot y^{-5}$      $\frac{1}{y^4}$

8.  $\frac{x^7}{x^{-7}}$      $x^{14}$

9.  $-5x^7 \cdot x^{-11} \cdot 2x^4$      $-10$

10.  $\frac{x^{-2}}{5z^0}$      $\frac{1}{5x^2}$

11.  $(w^2)^{-3}$      $\frac{1}{w^6}$

12.  $(8xy)^2$      $64x^2 y^2$

13.  $3x^5 \cdot (-2x)^4$      $48x^9$

14.  $(-5m^2 n^{-1})^3$      $-\frac{125m^6}{n^3}$

15.  $\frac{z^8}{z^{-2} \cdot z^9}$      $z$

16.  $\frac{(x^5)^3}{x^6}$      $x^9$

17.  $\left(\frac{3x}{2}\right)^3$      $\frac{27x^3}{8}$

18.  $\left(\frac{6x^4}{5y}\right)^{-2}$      $\frac{25y^2}{36x^8}$

19.  $\frac{xy^{-2}}{x^4 y^{-3}}$      $\frac{y}{x^3}$

20.  $\frac{8xy}{6x^5 yz^{-2}}$      $\frac{4z^2}{3x^4}$

21. **METRIC SYSTEM** There are  $10^6$  micrometers in a meter and  $10^3$  meters in a kilometer. How many micrometers are there in  $10^6$  kilometers?     $10^{15}$  micrometers