

**EXAMPLE 1****Evaluate numerical expressions**

**a.**  $(-4 \cdot 2^5)^2 = (-4)^2 \cdot (2^5)^2$  **Power of a product property**

$= 16 \cdot 2^5 \cdot 2$  **Power of a power property**

$= 16 \cdot 2^{10} = 16,384$  **Simplify and evaluate power.**

**b.**  $\left(\frac{11^5}{11^8}\right)^{-1} = \frac{11^8}{11^5}$  **Negative exponent property**

$= 11^{8-5}$  **Quotient of powers property**

$= 11^3 = 1331$  **Simplify and evaluate power.**

## EXAMPLE 2

### Use scientific notation in real life

Use Properties of Exponents

#### Locusts

A swarm of locusts may contain as many as 85 million locusts per square kilometer and cover an area of 1200 square kilometers. About how many locusts are in such a swarm?



#### SOLUTION

Number  
of locusts

=

Locusts per  
square kilometer

×

Number of square  
kilometers

$$= 85,000,000 \times 1200$$

**Substitute values.**

**EXAMPLE 2****Use scientific notation in real life**

$$= (8.5 \times 10^7)(1.2 \times 10^3)$$

**Write in scientific notation.**

$$= (8.5 \times 1.2)(10^7 \times 10^3)$$

**Use multiplication properties.**

$$= 10.2 \times 10^{10}$$

**Product of powers property**

$$= 1.02 \times 10^1 \times 10^{10}$$

**Write 10.2 in scientific notation.**

$$= 1.02 \times 10^{11}$$

**Product of powers property**

**ANSWER**

**The number of locusts is about  $1.02 \times 10^{11}$ , or about 102,000,000,000.**

**Evaluate the expression. Tell which properties of exponents you used.**

1.  $(4^2)^3$

**SOLUTION**

$$(4^2)^3 = 4^{2 \cdot 3}$$

**Power of a power property**

$$= 4096$$

**Simplify and evaluate power.**

2.  $(-8)(-8)^3$

**SOLUTION**

$$(-8)(-8)^3 = (-8)(-8)^3$$

**Product of a powers property**

$$= (-8)(-512)$$

**Multiply**

$$= 4096$$

**Simplify**

3.  $\left(\frac{2}{9}\right)^3$

**SOLUTION**

$$\begin{aligned}\left(\frac{2}{9}\right)^3 &= \left(\frac{2^3}{9^3}\right) \\ &= \left(\frac{8}{729}\right)\end{aligned}$$

**Power of a quotient property**

**Simplify and evaluate power.**

$$4. \quad \frac{6 \cdot 10^{-4}}{9 \cdot 10^7}$$

**SOLUTION**

$$\frac{6 \cdot 10^{-4}}{9 \cdot 10^7} = \frac{6}{9} \cdot 10^{-4-7} \quad \text{quotient of power property}$$

$$= \frac{6}{9} \cdot 10^{-11} \quad \text{add power}$$

$$= \frac{2}{3} \cdot 10^{-11} \quad \text{Negative exponent property}$$

$$= \frac{2}{3 \cdot 10^{11}} \quad \text{Negative exponent property}$$

**EXAMPLE 3****Simplify expressions**

a.  $b^{-4}b^6b^7 = b^{-4+6+7} = b^9$       **Product of powers property**

b.  $\left[\frac{r^{-2}}{s^3}\right]^{-3} = \frac{(r^{-2})^{-3}}{(s^3)^{-3}}$       **Power of a quotient property**

$= \frac{r^6}{s^{-9}}$       **Power of a power property**

$= r^6s^9$       **Negative exponent property**

c.  $\frac{16m^4n^{-5}}{2n^{-5}} = 8m^4n^{-5-(-5)}$       **Quotient of powers property**

$= 8m^4n^0 = 8m^4$       **Zero exponent property**



**EXAMPLE 4****Standardized Test Practice**

What is the simplified form of  $\frac{(x^{-3}y^3)^2}{x^5y^6}$ ?

(A)  $x^{11}$

(B)  $\frac{1}{x^{11}}$

(C)  $\frac{1}{x^6y}$

(D)  $\frac{1}{x^{11}y}$

**SOLUTION**

$$\begin{aligned}\frac{(x^{-3}y^3)^2}{x^5y^6} &= \frac{(x^{-3})^2(y^3)^2}{x^5y^6} \\ &= \frac{x^{-6}y^6}{x^5y^6}\end{aligned}$$

**Power of a product property**

**Power of a power property**

**EXAMPLE 4****Standardized Test Practice**

$$= x^{-6-5}y^{6-6}$$

Quotient of powers property

$$= x^{-11}y^0$$

Simplify exponents.

$$= x^{-11} \cdot 1$$

Zero exponent property

$$= \frac{1}{x^{11}}$$

Negative exponent property

**ANSWER**

The correct answer is **B**. (A) (B) (C) (D)

## EXAMPLE 5

### Compare real-life volumes

Use Properties of Exponents

#### Astronomy

**Betelgeuse is one of the stars found in the constellation Orion. Its radius is about 1500 times the radius of the sun. How many times as great as the sun's volume is Betelgeuse's volume?**



**EXAMPLE 5****Compare real-life volumes**

Use Properties of Exponents

**SOLUTION**

Let  $r$  represent the sun's radius. Then  $1500r$  represents Betelgeuse's radius.

$$\frac{\text{Betelgeuse's volume}}{\text{Sun's volume}} = \frac{\frac{4}{3} \pi (1500r)^3}{\frac{4}{3} \pi r^3}$$

The volume of a sphere is  $\frac{4}{3} \pi r^3$ .

$$= \frac{\cancel{\frac{4}{3}} \pi 1500^3 r^3}{\cancel{\frac{4}{3}} \pi r^3}$$

Power of a product property

**EXAMPLE 5****Compare real-life volumes**

$$= 1500^3 r^0$$

Quotient of powers  
property

$$= 1500^3 \cdot 1$$

Zero exponent property

$$= 3,375,000,000$$

Evaluate power.

**ANSWER**

**Betelgeuse's volume is about 3.4 billion times as great as the sun's volume.**

**Simplify the expression. Tell which properties of exponents you used.**

5.  $x^{-6}x^5x^3$

**SOLUTION**

$$x^{-6}x^5x^3 = x^{-6}x^{5+3}$$

$$= x^2$$

**Power of a product property**

**Simplify exponents.**

## GUIDED PRACTICE

## for Examples 3, 4, and 5

Use Properties of Exponents

6.  $(7y^2z^5)(y^{-4}z^{-1})$

### SOLUTION

$$\begin{aligned}(7y^2z^5)(y^{-4}z^{-1}) &= (7y^2z^5)(y^{-4}z^{-1}) && \text{Power of a product property} \\ &= (7y^{2-4})(z^{5+(-1)}) && \text{Simplify} \\ &= (7y^{-2})(z^4) && \text{Negative exponent property} \\ &= \frac{7z^4}{y^2}\end{aligned}$$

## GUIDED PRACTICE

## for Examples 3, 4, and 5

Use Properties of Exponents

7.  $\left(\frac{s^3}{t^{-4}}\right)^2$

### SOLUTION

$$\left(\frac{s^3}{t^{-4}}\right)^2 = \frac{s^{(3)2}}{(t^{-4})^2}$$

Power of a product property

$$= \frac{s^6}{t^{-8}}$$

Evaluate power.

$$= s^6 t^8$$

Negative exponent property



# GUIDED PRACTICE

## for Examples 3, 4, and 5

Use Properties of Exponents

8.  $\left[ \frac{x^4 y^{-2}}{x^3 y^6} \right]^3$

### SOLUTION

$$\left[ \frac{x^4 y^{-2}}{x^3 y^6} \right]^3 = \frac{(x^4)^3 (y^{-2})^3}{(x^3)^3 (y^6)^3}$$

Power of a powers property

$$= \frac{x^{12} y^{-6}}{x^9 y^{18}}$$

Power of a powers property

$$= x^3 y^{-24}$$

Power of a Quotient property

$$= \frac{x^3}{y^{24}}$$

Negative exponent property