

# 5.1 Use Properties of Exponents

## Properties

$$a^m \cdot a^n = a^{m+n}$$

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

$$(a^m)^n = a^{mn}$$

$$(ab)^m = a^m b^m$$

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

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

$$a^0 = 1$$

$$2^3 \cdot 2^5 = 2^8$$

$$\frac{3^6}{3^2} = 3^4$$

$$(5^2)^5 = 5^{10}$$

$$(5x)^2 = 5^2 x^2$$

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

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

**EXAMPLE 1** Evaluate numerical expressions

$$\left(\frac{11^5}{11^8}\right)^{-1}$$
$$(11^{5-8})^{-1}$$

$$(11^{-3})^{-1}$$

$$11^{-3 \cdot -1} = 11^3 = 1331$$

$$(-8)^1(-8)^3$$

$$(-8)^4 = 4096$$

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

$$\frac{2^3}{9^3} = \frac{8}{729}$$

$$4^6$$

$$(4^2)^3 = 4^6$$

$$4096$$

**EXAMPLE 3** Simplify expressions

$$b^{-4}b^6b^7$$

$$b^{-4+6+7} = \boxed{b^9}$$

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

$$x^{-6+5+3} = \boxed{x^2}$$

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

$$\frac{r^{-2 \cdot -3}}{s^{3 \cdot -3}} = \frac{r^6}{s^{-9}}$$

$$= \boxed{r^6 s^9}$$

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

$$\frac{s^{3 \cdot 2}}{t^{-4 \cdot 2}} = \frac{s^6}{t^{-8}}$$

$$= \boxed{s^6 t^8}$$

$$\frac{16m^4 n^{-5}}{2n^{-5}}$$

$$\frac{8m^4 \cancel{n^{-5}}}{\cancel{2n^{-5}}} \quad \uparrow \quad -5 \neq 5$$

$$8m^4 n^0 = \boxed{8m^4}$$

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

$$\frac{7^{-2} y^4 z^4}{y^2}$$

**EXAMPLE 4**

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

$$\frac{x^{-6}y^6}{x^5y^6} = x^{-6-5}y^{6-6} = x^{-11} = \frac{1}{x^{11}}$$
$$\frac{x^{-6}}{x^5} = \frac{1}{x^5 \cdot x^6} = \frac{1}{x^{5+6}} = \frac{1}{x^{11}}$$

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

**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?

$$\frac{\text{locusts}}{\cancel{\text{km}^2}} \cdot \cancel{\text{km}^2} = \text{locusts}$$

$$(85,000,000)(1200)$$

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

$$(8.5 \cdot 1.2) \times 10^{7+3} = 10.2 \times 10^{10}$$

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

**EVALUATING NUMERICAL EXPRESSIONS** Evaluate the expression.

3.  $3^3 \cdot 3^2$

$$3^{3+2} = 3^5 = 81 \cdot 3 = \boxed{243}$$

**SCIENTIFIC NOTATION** Write the answer in scientific notation.

15.  $(4.2 \times 10^3)(1.5 \times 10^6)$

$$(4.2 \cdot 1.5) \times 10^{3+6}$$

$$\boxed{6.3 \times 10^9}$$


**SIMPLIFYING ALGEBRAIC EXPRESSIONS** Simplify the expression.

27.  $(w^3x^{-2})(w^6x^{-1})$

$$w^{3+6} x^{-2+-1}$$
$$w^9 x^{-3}$$

$$\boxed{\frac{w^9}{x^3}}$$



 **GEOMETRY** Write an expression for the figure's area or volume in terms of  $x$ .

$$40. A = \frac{\sqrt{3}}{4}s^2 = \frac{\sqrt{3}}{4} \left(\frac{x}{3}\right)^2 = \frac{\sqrt{3}}{4} \cdot \frac{x^2}{3^2} = \frac{x^2\sqrt{3}}{36}$$

