SIMPLIFY EXPRESSIONS

When simplifying powers with numerical *and* variable bases, be sure to evaluate the numerical power, as in parts (b), (c), and (d).

EXAMPLE 3 Use the power of a product property

a. $(24 \cdot 13)^8 = 24^8 \cdot 13^8$

b. $(9xy)^2 = (9 \cdot x \cdot y)^2 = 9^2 \cdot x^2 \cdot y^2 = 81x^2y^2$

c. $(-4z)^2 = (-4 \cdot z)^2 = (-4)^2 \cdot z^2 = 16z^2$

d. $-(4z)^2 = -(4 \cdot z)^2 = -(4^2 \cdot z^2) = -16z^2$

EXAMPLE 4 Use all three properties

Simplify $(2x^3)^2 \cdot x^4$.

$(2x^3)^2 \cdot x^4 = 2^2 \cdot (x^3)^2 \cdot x^4$ Power of a product property

$= 4 \cdot x^6 \cdot x^4$ Power of a power property

$= 4x^{10}$ Product of powers property

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ORDER OF MAGNITUDE The **order of magnitude** of a quantity can be defined as the power of 10 nearest the quantity. Order of magnitude can be used to estimate or perform rough calculations. For instance, there are about 91,000 species of insects in the United States. The power of 10 closest to 91,000 is 10^5, or 100,000. So, there are about 10^5 species of insects in the United States.

EXAMPLE 5 Solve a real-world problem

BEES In 2003 the U.S. Department of Agriculture (USDA) collected data on about 10^3 honeybee colonies. There are about 10^4 bees in an average colony during honey production season. About how many bees were in the USDA study?

Solution

To find the total number of bees, find the product of the number of colonies, 10^3, and the number of bees per colony, 10^4.

$10^3 \cdot 10^4 = 10^{3+4} = 10^7$

▶ The USDA studied about 10^7, or 10,000,000, bees.

✓ GUIDED PRACTICE for Examples 3, 4, and 5

Simplify the expression.

9. $(42 \cdot 12)^2$ **10.** $(-3n)^2$ **11.** $(9m^3n)^4$ **12.** $5 \cdot (5x^2)^4$

13. WHAT IF? In Example 5, 10^2 honeybee colonies in the study were located in Idaho. About how many bees were studied in Idaho?