Lesson 5–1

Example 1 Simplify Expressions with Multiplication

Simplify $(-5a^5x)(-9a^3x^7)$.

$(-5a^5x)(-9a^3x^7) = (-5 \cdot a \cdot a \cdot a \cdot a \cdot a \cdot x)(-9 \cdot a \cdot a \cdot a \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x)$ Definition of exponents

$= (-5)(-9) \cdot a \cdot a \cdot a \cdot a \cdot a \cdot a \cdot a \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x \cdot x$ Commutative Property

$= 45a^8x^8$ Definition of exponents

Example 2 Simplify Expressions with Division

Simplify $\dfrac{-15c^2d}{3cd^4}$. Assume that $c, d \neq 0$.

$\dfrac{-15c^2d}{3cd^4} = \left(\dfrac{-15}{3}\right) \cdot c^{2-1}d^{1-4}$ Subtract exponents.

$= -5cd^{-3}$ or $\dfrac{-5c}{d^3}$ Remember that a simplified expression cannot contain negative exponents.

Check

$$\frac{-15c^2d}{3cd^4} = \frac{\overset{-5}{\cancel{-15}} \cdot \overset{1}{\cancel{c}} \cdot c \cdot \overset{1}{\cancel{d}}}{\underset{1}{\cancel{3}} \cdot \underset{1}{\cancel{c}} \cdot \underset{1}{\cancel{d}} \cdot d \cdot d \cdot d}$$ Definition of exponents.

$= \dfrac{-5c}{d^3}$ ✓ Simplify.

Example 3 Simplify Expressions with Powers

Simplify each expression.

a. $(m^2)^5$

$(m^2)^5 = m^{2(5)}$ Power of a power

$= m^{10}$

b. $(-3a^3b^5)^3$

$(-3a^3b^5)^3 = (-3)^3 \cdot (a^3)^3 \cdot (b^5)^3$ Power of a power

$= -27a^9b^{15}$ $(-3)^3 = -27$

c. $\left(\dfrac{2m^2}{n^4}\right)^3$

$\left(\dfrac{2m^2}{n^4}\right)^3 = \dfrac{(2m^2)^3}{(n^4)^3}$ Power of a quotient

$= \dfrac{(2)^3(m^2)^3}{(n^4)^3}$ Power of a product

$= \dfrac{8m^6}{n^{12}}$ $(2)^3 = 8$

d. $\left(\dfrac{2}{x}\right)^{-4}$

$\left(\dfrac{2}{x}\right)^{-4} = \left(\dfrac{x}{2}\right)^4$ Power of a quotient

$= \dfrac{x^4}{2^4}$

$= \dfrac{x^4}{16}$ $2^4 = 16$

Example 4 Simplify Expressions Using Several Properties

Simplify $\left(\frac{18a^{4x}b^2}{-6a^x b^5}\right)^3$.

Method 1

Raise the numerator and denominator to the third power before simplifying.

$$\left(\frac{18a^{4x}b^2}{-6a^x b^5}\right)^3 = \frac{(18a^{4x}b^2)^3}{(-6a^x b^5)^3}$$

$$= \frac{(18)^3(a^{4x})^3(b^2)^3}{(-6)^3(a^x)^3(b^5)^3}$$

$$= \frac{5832a^{12x}b^6}{-216a^{3x}b^{15}}$$

$$= -27a^{12x-3x}b^{6-15}$$

$$= -27a^{9x}b^{-9} \text{ or } -\frac{27a^{9x}}{b^9}$$

Method 2

Simplify the fraction before raising to the third power.

$$\left(\frac{18a^{4x}b^2}{-6a^x b^5}\right)^3 = (-3a^{4x-x}b^{2-5})^3$$

$$= \left(-\frac{3a^{3x}}{b^3}\right)^3$$

$$= -\frac{27a^{9x}}{b^9}$$

Example 5 Express Numbers in Scientific Notation

Express each number in scientific notation.

a. 0.000103

$0.000103 = 1.03 \times 0.0001$ $\quad 1 \le 1.03 < 10$

$= 1.03 \times \frac{1}{10^4}$ $\quad 0.0001 = \frac{1}{10,000}$ or $\frac{1}{10^4}$

$= 1.03 \times 10^{-4}$ $\quad$ Use a negative exponent.

b. 72,340,000

$72,340,000 = 7.234 \times 10,000,000$ $\quad 1 \le 7.234 < 10$

$= 7.234 \times 10^7$ $\quad$ Write 10,000,000 as a power of 10.

Example 6 Multiply Numbers in Scientific Notation

Evaluate. Express the result in scientific notation.

a. $(1.5 \times 10^{-2})(6 \times 10^{-6})$

$(1.5 \times 10^{-2})(6 \times 10^{-6}) = (1.5 \cdot 6) \times (10^{-2} \cdot 10^{-6})$ $\quad$ Associative and Commutative Properties

$= 9 \times 10^{-8}$ $\quad 1.5 \cdot 6 = 9,\ 10^{-2} \cdot 10^{-6} = 10^{-2+(-6)} = 10^{-8}$

b. $(3.1 \times 10^{-3})(2 \times 10^5)$

$(3.1 \times 10^{-3})(2 \times 10^5) = (3.1 \cdot 2) \times (10^{-3} \cdot 10^5)$ $\quad$ Associative and Commutative Properties

$= 6.2 \times 10^2$ $\quad 3.1 \cdot 2 = 6.2,\ 10^{-3} \cdot 10^5 = 10^{-3+5} = 10^2$

Example 7 Divide Numbers in Scientific Notation

ASTRONOMY Neptune is about 4.5×10^{12} meters from the Sun. If light travels about 3.00×10^{8} meters per second, how long does the light from the Sun to reach Neptune?

Begin with the formula $d = rt$, where d is distance, r is rate, and t is time.

$t = \dfrac{d}{r}$ Solve the formula for time.

$= \dfrac{4.5 \times 10^{12}}{3.00 \times 10^{8}}$ ← Distance from Sun to Neptune ← Speed of light

$= \dfrac{4.5}{3.00} \times \dfrac{10^{12}\ \text{m}}{10^{8}\ \text{m/s}}$ **Estimate:** The result should be slightly greater than $\dfrac{10^{12}}{10^{8}}$ or 10^{12-8} or 10^{4}.

$= 1.5 \times 10^{4}$ $\dfrac{4.5}{3.00} = 1.5$, $\dfrac{10^{12}}{10^{8}} = 10^{12-8}$ or 10^{4}

It takes about 1.5×10^{4} seconds or just over 4 hours for light from the Sun to reach Neptune.