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6-4 Exponents and Division

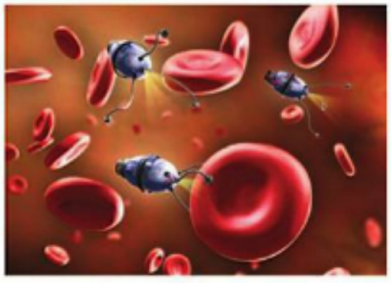
CONTENT STANDARDS
8.EE.1

What You'll Learn

To divide powers with the same base and to simplify expressions with negative exponents

Why Learn This?

Nanorobots are microscopic machines that may soon be used to fight illness inside the human body. When working with very small numbers, such as the length of a nanorobot, you often divide expressions with exponents.



You can divide powers with the same base by writing out all the factors.

$$\frac{7^5}{7^3} = \frac{\cancel{7}^{1} \cdot \cancel{7}^{1} \cdot \cancel{7}^{1} \cdot 7 \cdot 7}{\cancel{7} \cdot \cancel{7} \cdot \cancel{7}} = \frac{7 \cdot 7}{1} = 7^2$$

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Notice that $5 - 3 = 2$. This example suggests the following rule.

KEY CONCEPTS **Dividing Powers With the Same Base**

To divide nonzero numbers or variables with the same nonzero base, subtract the exponents.

Arithmetic	Algebra
$\frac{8^5}{8^3} = 8^{(5-3)} = 8^2$	$\frac{a^m}{a^n} = a^{(m-n)}$, where $a \neq 0$

Key Concepts

Dividing Powers With the Same Base

To divide nonzero numbers or variables with the same nonzero base, [subtract] the exponents.

Arithmetic	Algebra
$\frac{8^5}{8^3} = 8^{(5 \boxed{-} 3)} = 8^{\boxed{2}}$	$\frac{a^m}{a^n} = a^{(m \boxed{-} n)}$, where $a \neq 0$.

Zero as an Exponent

For any nonzero number a, $a^0 = \boxed{1}$.

Example $9^0 = \boxed{1}$

Negative Exponents

For any nonzero number a and integers n, $a^{-n} = \frac{1}{\boxed{a^n}}$.

Example $8^{\boxed{-5}} = \frac{1}{8^5}$.

EXAMPLE 1 Dividing Powers

Write $\frac{m^{12}}{m^5}$ using a single exponent.

$$\frac{m^{12}}{m^5} = m^{(12 - 5)} \quad \leftarrow \text{Subtract exponents with the same base.}$$

$$= m^7 \quad \leftarrow \text{Simplify.}$$

Examples

1 Dividing Powers Write $\frac{x^{14}}{x^9}$ using a single exponent.

$$\frac{x^{14}}{x^9} = x^{(14 \boxed{-} 9)} \quad \leftarrow \boxed{\text{Subtract}} \text{ exponents with the same base.}$$

$$= x^{\boxed{5}} \quad \leftarrow \text{Simplify.}$$

What does the exponent 0 mean? Consider finding the quotient $\frac{3^5}{3^5}$.

If you subtract exponents, $\frac{3^5}{3^5} = 3^{(5-5)} = 3^0$.

If you write factors, $\frac{3^5}{3^5} = \frac{\cancel{3}^1 \cdot \cancel{3}^1 \cdot \cancel{3}^1 \cdot \cancel{3}^1 \cdot \cancel{3}^1}{{}_1\cancel{3} \cdot {}_1\cancel{3} \cdot {}_1\cancel{3} \cdot {}_1\cancel{3} \cdot {}_1\cancel{3}}$

$= \frac{1}{1} = 1.$

Notice that $\frac{3^5}{3^5} = 3^0$ and $\frac{3^5}{3^5} = 1$. This suggests the following rule.

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KEY CONCEPTS **Zero as an Exponent**

For any nonzero number a, $a^0 = 1$.

Example $9^0 = 1$

EXAMPLE **Expressions With a Zero Exponent**

2 Simplify each expression.

a. $(-8)^0$

$(-8)^0 = 1$ ← Simplify. →

b. $3m^0$

$3m^0 = 3 \cdot 1 = 3$

❷ Expression With a Zero Exponent Simplify each expression.

a. $(-5)^0$

$(-5)^0 = \boxed{1}$ ← Simplify.

b. $2y^0, y \neq 0$

$2y^0 = \boxed{2}$ ← Simplify.

To understand negative exponents, consider finding the quotient $\frac{6^2}{6^5}$.

If you subtract exponents, $\frac{6^2}{6^5} = 6^{(2-5)} = 6^{-3}$.

If you write factors, $\frac{6^2}{6^5} = \frac{6^1 \cdot 6^1}{{}_1\cancel{6} \cdot {}_1\cancel{6} \cdot 6 \cdot 6 \cdot 6}$

$= \frac{1}{6 \cdot 6 \cdot 6} = \frac{1}{6^3}$.

Notice that $\frac{6^2}{6^5} = 6^{-3}$ and $\frac{6^2}{6^5} = \frac{1}{6^3}$. This suggests the following rule.

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KEY CONCEPTS **Negative Exponents**

For any nonzero number a and integer n, $a^{-n} = \frac{1}{a^n}$.

Example $8^{-5} = \frac{1}{8^5}$

To simplify an expression with negative exponents, you can first write the expression with a positive exponent.

EXAMPLE 3 Expressions With Negative Exponents

Simplify each expression.

a. 3^{-2}

$3^{-2} = \frac{1}{3^2}$ ← Use a positive exponent. → $= \frac{1}{9}$ ← Simplify.

b. $(y)^{-6}$

$(y)^{-6} = \frac{1}{y^6}$

Expressions With Negative Exponents Simplify each expression.

a. 2^{-3}

$2^{-3} = \frac{1}{2^{3}}$ ← Use a positive exponent. → $= \frac{1}{8}$ ← Simplify.

b. $(p)^{-8}$

$= \frac{1}{p^{8}}$

More Than One Way

Simplify the expression $4^3 \cdot 4^{-5}$.

Tina's Method

I can rewrite the expression with positive exponents.

$4^3 \cdot 4^{-5} = 4^3 \cdot \frac{1}{4^5}$ ← Use a positive exponent.

$= \frac{4^3}{4^5}$ ← Multiply fractions.

$= 4^{(3-5)}$ ← Subtract exponents with the same base.

$= 4^{-2}$ ← Simplify.

$= \frac{1}{4^2}$ ← Use a positive exponent.

$= \frac{1}{16}$ ← Simplify.

So the expression is equal to $\frac{1}{16}$.

Eric's Method

To multiply numbers with the same base, I can add the exponents.

$4^3 \cdot 4^{-5} = 4^{(3+(-5))}$ ← Add the exponents.

$= 4^{-2}$ ← Simplify.

$= \frac{1}{4^2}$ ← Use a positive exponent.

$= \frac{1}{16}$ ← Simplify.

So the expression is equal to $\frac{1}{16}$.

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wait for me to start your assignment (6 questions)

Name _____ Class _____ Date _____

6-4 • Guided Problem Solving

GPS **Student Page 197, Exercise 24:**

Earth Science Earth's crust is divided into large pieces called tectonic plates. The Pacific tectonic plate is moving northwest at a rate of about 4^{-2} m each year. At this rate, how long will it take the plate to move 4^6 m (about 2.5 miles)?

Understand

1. The equation $d = rt$ represents the relationship between distance d, rate r, and time t. What measurements are given in the problem?

_____

2. What measurement are you asked to find?

_____

Plan and Carry Out

3. Solve the equation $d = rt$ for t.

_____

4. Substitute the values that are known into the equation for t.

_____

5. What is the common base?

_____

6. When dividing powers with the same base, what do you do to the exponents?

_____

7. Solve the equation for t.

_____

Check

8. Solve the problem by writing the numbers in standard form. Does your answer check?

_____

Solve Another Problem

9. A rectangular plot of land covers an area of 2^{13} square feet. You measure the length of the plot to be 2^7 feet. What is the width?

_____