1.3 Quotient of Powers Property

Learning Target: Generate equivalent expressions involving quotients of powers.

Success Criteria:
- I can find quotients of powers that have the same base.
- I can simplify expressions using the Quotient of Powers Property.
- I can solve real-life problems involving quotients of powers.

Number Sense and Operations
MA.7.NSO.1.1 Know and apply the Laws of Exponents to evaluate numerical expressions and generate equivalent numerical expressions, limited to whole-number exponents and rational number bases.

Exploration 1 Finding Quotients of Powers

Work with a partner.

a. Complete the table. Use your results to write a *general rule* for finding $\frac{a^m}{a^n}$, a quotient of two powers with the same base.

Quotient	Repeated Multiplication Form	Power
$\frac{2^4}{2^2}$	$\frac{\cancel{2} \cdot \cancel{2} \cdot 2 \cdot 2}{\cancel{2} \cdot \cancel{2}}$	2^2
$\frac{7^7}{7^3}$	$\frac{\cancel{7} \cdot \cancel{7} \cdot \cancel{7} \cdot 7 \cdot 7 \cdot 7 \cdot 7}{\cancel{7} \cdot \cancel{7} \cdot \cancel{7}}$	7^4
$\frac{10^8}{10^5}$	$\frac{\cancel{10} \cdot \cancel{10} \cdot \cancel{10} \cdot \cancel{10} \cdot \cancel{10} \cdot 10 \cdot 10 \cdot 10}{\cancel{10} \cdot \cancel{10} \cdot \cancel{10} \cdot \cancel{10} \cdot \cancel{10}}$	10^3

when there is a fraction bar between the same base, subtract exponents

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1.3 Lesson

Key Ideas

Quotient of Powers Property

Words To divide powers with the same base, subtract their exponents.

Numbers $\dfrac{4^5}{4^2} = 4^{5-2} = 4^3$

Algebra $\dfrac{a^m}{a^n} = a^{m-n}$, where $a \neq 0$

Zero Exponents

Words For any nonzero number a, $a^0 = 1$. The power 0^0 is *undefined*.

Numbers $4^0 = 1$

Algebra $a^0 = 1$, where $a \neq 0$

Example 1 Dividing Powers with the Same Base

Common Error

When dividing powers, do not divide the bases.

$\dfrac{2^6}{2^4} = 2^2$, not 1^2.

Simplify $\dfrac{2^6}{2^4}$. Write your answer as a power.

$\dfrac{2^6}{2^4} = 2^{6-4}$ Quotient of Powers Property

$= 2^2$ Simplify.

Try It **Simplify the expression. Write your answer as a power.**

1. $\dfrac{9^7}{9^4}$

9^3

2. $\dfrac{4^6}{4^5}$

4^1 or just 4

3. $\dfrac{8^8}{8^4}$

8^4

4. $\dfrac{5^3}{5^3}$

$5^0 = 1$

Example 2 Simplifying an Expression

Simplify $\dfrac{3^4 \cdot 3^2}{3^3}$. Write your answer as a power.

$3^4 \cdot 3^2 = \dfrac{3^6}{3^3}$

$= 3^3$

The numerator is a product of powers. Add the exponents in the numerator.

$\dfrac{3^4 \cdot 3^2}{3^3} = \dfrac{3^{4+2}}{3^3}$ Product of Powers Property

$= \dfrac{3^6}{3^3}$ Simplify.

$= 3^{6-3}$ Quotient of Powers Property

$= 3^3$ Simplify.

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Try It Simplify the expression. Write your answer as a power.

5. $\frac{6^7 \cdot 6^3}{6^5}$

$\frac{6^{10}}{6^5} = 6^5$

6. $\frac{2^{15}}{2^3 \cdot 2^5}$

$\frac{2^{15}}{2^8} = 2^7$

7. $\frac{4^8 \cdot 4^6}{4^5}$

$\frac{4^{14}}{4^5} = 4^9$

Example 3 Simplifying Expressions

$4^9 + 4^8 = 4^{17}$ $\frac{4^{17}}{4^7} = 4^{10}$

2 MTR USE ANOTHER METHOD
Show how you can simplify the expressions in parts (a) and (b) by first multiplying the numerators and then multiplying the denominators.

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a. $\frac{4^9}{4^5} \cdot \frac{4^8}{4^2} = 4^{9-5} \cdot 4^{8-2}$ or Quotient of Powers Property

$= 4^4 \cdot 4^6$ Simplify.

$= 4^{4+6}$ Product of Powers Property

$= 4^{10}$ Simplify.

b. $\frac{9^{10}}{9^6} \cdot \frac{9^7}{9^4} = 9^{10-6} \cdot 9^{7-4}$ Quotient of Powers Property

$= 9^4 \cdot 9^3$ Simplify.

$= 9^{4+3}$ Product of Powers Property

$= 9^7$ Simplify.

c. $5^3 \cdot 3^0 = 5^3 \cdot 1$ Definition of a zero exponent

$= 5^3$ Multiplicative Identity Property of One

Try It Simplify the expression. Write your answer as a power.

8. $\frac{5^7 \cdot 5^6}{5^5 \cdot 5^2}$

$\frac{5^{13}}{5^7} = 5^6$

9. $\frac{7^5}{7^1} \cdot \frac{7^9}{7^8}$

$\frac{7^{14}}{7^9} = 7^5$

10. $2^5 \cdot 8^0$

$2^5 \cdot 1$

2^5

do word problem on pg 28

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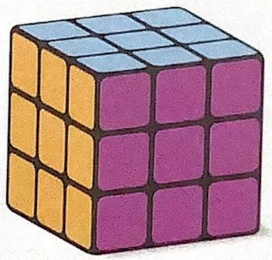
Example 4 Modeling Real Life

7 MTR

A warehouse is shipping boxes of cube-shaped puzzles to a store. The volume of a puzzle is 2^3 cubic inches. The puzzles can fit in a box with no space left over. The volume of the box is $8 \cdot 2^6$ cubic inches. How many puzzles can fit in the box?

You can find the number of puzzles that can fit in the box by dividing the volume of the box by the volume of a puzzle.



$$\text{Number of puzzles} = \frac{\text{Volume of the box}}{\text{Volume of a puzzle}}$$

$= \dfrac{8 \cdot 2^6}{2^3}$ Substitute.

$= 8 \cdot \dfrac{2^6}{2^3}$ Rewrite.

$= 8 \cdot 2^3$ Quotient of Powers Property

$= 8 \cdot 8$ Evaluate the power.

$= 64$ Simplify.

▶ So, 64 cube-shaped puzzles can fit in the box.

In-Class Practice

1 I don't understand yet. 2 I can do it with help. 3 I can do it on my own. 4 I can teach someone else.

18. A warehouse is shipping crates of cube-shaped boxes. The volume of a box is 2^6 cubic inches. The boxes can fit in a shipping crate with no space left over. The volume of the crate is $27 \cdot 2^9$ cubic inches. How many boxes can fit in the crate?

$\dfrac{27 \cdot 2^9}{2^6}$ $27 \cdot 2^3$ $27 \cdot 8 = 216$

19. You want to purchase a cat tracker. Tracker A detects your cat within a distance of $4 \cdot 10^2$ feet of your home. Tracker B detects your cat within a distance of 10^4 feet of your home. Which tracker covers a greater distance from your home? How many times greater?

20. **Dig Deeper** An earthquake of magnitude 3.0 is 10^2 times stronger than an earthquake of magnitude 1.0. An earthquake of magnitude 8.0 is 10^7 times stronger than an earthquake of magnitude 1.0. How many times stronger is an earthquake of magnitude 8.0 than an earthquake of magnitude 3.0?

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