Lesson 3

APPLY PROPERTIES OF INTEGER EXPONENTS 8.EE.A.1

WORDS TO KNOW

base

exponent

INTRODUCTION

Real-World Connection

Connor and Helen are playing a math matching game. It is Connor's turn and he has to try to find one of Helen's cards that matches the value of the card in his hand. Let's practice the skills in the **Guided Instruction** and **Independent Practice** and see if Connor finds his match at the end of the lesson!

Connor's card	Helen's cards		
$\frac{1}{8}$	2^{-3}	$\left(\frac{1}{2}\right)^2$	$(2^2)^4$

What I Am Going to Learn

- How to apply the properties of integer exponents to find equivalent expressions
- How to change a negative integer exponent into a positive integer exponent

What I May Already Know 6.EE.A.1, 6.NS.C.7.c

- I know how to write and evaluate numerical expressions involving whole-number exponents.
- I know that the absolute value of a rational number is its distance from zero on a number line.

Vocabulary in Action

- In the expression a^n, a is the **base** and n is the **exponent**.
- To simplify an expression with an exponent, multiply a repeatedly.
- Write the value of a, n times: $a^n = \underbrace{a \cdot a \cdot a \ldots \cdot a}_{n \text{ times}}$

THINK ABOUT IT

Can you write the number 16 using two different bases and two different exponents?

EXAMPLE

Simplify the expression 5^4.

This expression means that 5 is being multiplied by itself 4 times.

$5^4 = 5 \times 5 \times 5 \times 5 = 625$

Exponents are used in many ways to show the spread of information. If one person tells another five people, and then each of those people tell another five people, the original piece of information, like a social media message or a news item, spreads rapidly or "goes viral."

TURN AND TALK

Work with a partner and write the expression below using a base and an exponent.

$(-w) \times (-w) \times (-w) = ?$

EXAMPLE

Compare the expressions $(-5)^4$ and $-(5)^4$.

- $(-5)^4 = (-5) \times (-5) \times (-5) \times (-5) = 625$

  Everything in parentheses gets multiplied.

- $-(5^4) = -5^4 = -(5 \times 5 \times 5 \times 5) = -(625) = -625$

  Only the 5 gets multiplied.

EXAMPLE

Simplify the expression $(5)^{-4}$.

If the exponent is a negative number, write the base and the absolute value of the exponent in the denominator of a fraction.

The exponent of $(5)^{-4}$ is negative. The absolute value of the exponent is 4.

$5^{-4} = \frac{1}{5^4} = \frac{1}{5 \times 5 \times 5 \times 5} = \frac{1}{625}$

You can use properties of exponents to evaluate expressions that include operations, such as multiplication and division. The chart below summarizes these properties and provides an example of each. For all properties, assume that a does not equal zero.

Property	Example
Product of Powers: When multiplying and the bases are the same, add the exponents: $a^b \times a^c = a^{b+c}$	$3^2 \times 3^3 = 3^5 = 243$
Quotient of Powers: When dividing and the bases are the same, subtract the exponents: $\frac{a^b}{a^c} = a^{b-c}$	$\frac{2^5}{2^3} = 2^{5-3} = 2^2 = 4$
Power of a Product: When multiplying and the exponents are the same, multiply the bases: $a^c \times b^c = (ab)^c$	$4^2 \times 3^2 = (4 \times 3)^2 = 12^2 = 144$
Power of a Quotient: When a quotient is raised to an exponent, apply the exponent to both bases: $\left(\frac{a}{b}\right)^c = \frac{a^c}{b^c}$	$\left(\frac{2}{3}\right)^2 = \frac{2^2}{3^2} = \frac{4}{9}$
Power of a Power: When a power is raised to a power, multiply the exponents: $(a^b)^c = a^{b \times c}$	$(3^2)^4 = 3^{2 \times 4} = 3^8 = 6{,}561$

TIPS AND TRICKS

Remember that a negative exponent does not necessarily make the simplified answer negative. On a calculator, evaluate, 2^{-2} and $(-2)^{-2}$ to see this point.

There is a special rule for all expressions with an exponent of zero. Any base (other than zero) raised to the power of zero equals 1: $a^0 = 1$, where $a \neq 0$. For example, 7^0 and $(-7)^0$ both equal 1.

GUIDED INSTRUCTION

1. Simplify the expression 4^{-3}.

Step One Rewrite this expression with a positive exponent. Write a fraction with a numerator of 1, and the base and exponent as the denominator, and eliminate the negative sign. $\frac{1}{4^3}$

Step Two Apply the exponent. $\frac{1}{4 \times 4 \times 4}$

Step Three Simplify. $\frac{1}{64}$

THINK ABOUT IT

Are exponents the same as coefficients? Is $4 \times -3 = 4^{-3}$?

HINT, HINT

Simplify a negative power by turning it into a fraction.

2. Use the numbers in the box to make equivalent expressions. The numbers cannot be used more than once. Write each number in the appropriate box.

256	$\frac{1}{16}$	-8	16

$4^{-2} =$ ☐ $\qquad -(2^3) =$ ☐

$\frac{2^9}{2^5} =$ ☐ $\qquad 4^2 \times 4^2 =$ ☐

How Am I Doing?

What questions do you have?

How can you simplify a negative power?

Describe a situation where you would want to change a negative power into a positive fraction.

Color in the traffic signal that shows how you are doing with the skill.

INDEPENDENT PRACTICE

Answer the questions.

1. Select the expression that is equivalent to 5^{-2}.

   Ⓐ $\frac{1}{25}$
   Ⓑ $\frac{1}{5}$
   Ⓒ -5^2
   Ⓓ $(5^{-1})^{-1}$

2. What is $4^2 \times 4^{-3}$?
   Write your answer in the box as a fraction in simplest form.

3. What is the value of $\frac{6^{-2}}{6^2}$?
   Write your answer in the box as a fraction in simplest form.

4. Which expressions are equivalent to $\frac{1}{9}$? Select the three correct answers.

   Ⓐ 9^{-1}
   Ⓑ 90
   Ⓒ $\left(\frac{1}{3}\right)^2$
   Ⓓ $9^5 \times 9^{-4}$
   Ⓔ -3^2
   Ⓕ $\frac{3^{-2}}{1}$

5. Which expression is equivalent to $2^2 \times 2^{-6}$?

   Ⓐ $\frac{1}{256}$
   Ⓑ $\frac{1}{16}$
   Ⓒ 16
   Ⓓ 256

TIPS AND TRICKS

Simplify the given expression first. Then simplify the answer choices, one at a time, and compare each one to the original expression.

HINT, HINT

What are the rules for dividing powers with the same base?

TIPS AND TRICKS

Simplify the expression. Then compare your steps to the steps listed in the answer choices.

WORK SPACE

6. Draw lines to show the steps for simplifying $-(3^{-2})$.

$-\left(\frac{1}{9}\right)$	1
$-\left(\frac{1}{3 \times 3}\right)$	2
$-\frac{1}{9}$	3
$-\left(\frac{1}{3^2}\right)$	4

7. Which expression is equivalent to $3^{-1} \times 3^2$?

Ⓐ $\frac{1}{27}$ Ⓑ $\frac{1}{3}$

Ⓒ 3 Ⓓ 27

8. Part A

India says that $(3^3)^2$ is equivalent to 243 because the exponents should be added when simplifying the expression. Explain why India is incorrect.

Part B

Write the value of $(3^3)^2$ in simplest form in the box.

9. Brendan says that $\frac{4^3}{4^5}$ is equivalent to $\frac{1}{16}$. Is he correct? Explain.

EXIT TICKET

8.EE.A.1

Now that you have mastered applying properties of integer exponents, let's solve the problem in the Real-World Connection.

In Connor and Helen's math matching game, it is Connor's turn. He has to try to find one of Helen's cards that matches the value of the card in his hand. Simplify each of Helen's cards, and then decide which card Connor should choose.

Connor's card	Helen's cards		
$\frac{1}{8}$	2^{-3}	$\left(\frac{1}{2}\right)^2$	$(2^2)^4$