Name _____ Class _____ Date _____

6-1

Integer Exponents

Going Deeper

Essential question: *How can you develop and use the properties of integer exponents?*

Video Tutor

PREP FOR CC.9-12.N.RN.1

1 EXPLORE **Using Patterns of Integer Exponents**

The table below shows powers of 5, 4, and 3.

$5^4 = 625$	$5^3 = 125$	$5^2 = 25$	$5^1 = 5$	$5^0 =$	$5^{-1} =$	$5^{-2} =$
$4^4 = 256$	$4^3 = 64$	$4^2 = 16$	$4^1 = 4$	$4^0 =$	$4^{-1} =$	$4^{-2} =$
$3^4 = 81$	$3^3 = 27$	$3^2 = 9$	$3^1 = 3$	$3^0 =$	$3^{-1} =$	$3^{-2} =$

A What pattern do you see in the powers of 5?

_____

_____

B What pattern do you see in the powers of 4?

_____

_____

C Complete the table for the values of 5^0, 5^{-1}, 5^{-2}.

D Complete the table for the values of 4^0, 4^{-1}, 4^{-2}.

E Complete the table for the values of 3^0, 3^{-1}, 3^{-2}.

F **Conjecture** Write a general rule for the values of a^0 and a^{-n} based on the patterns in the table.

_____

REFLECT

1a. Do the general rules you wrote in Part F for a^0 and a^{-n} apply when $a = 0$? Explain.

_____

_____

_____

PREP FOR CC.9-12.N.RN.1

2 EXPLORE Applying Properties of Integer Exponents

A Complete the following equations.

$3 \cdot 3 \cdot 3 \cdot 3 \cdot 3 = 3$ ____

$(3 \cdot 3 \cdot 3 \cdot 3) \cdot 3 = 3$ ____ $\cdot 3$ ____ $= 3$ ____

$(3 \cdot 3 \cdot 3) \cdot (3 \cdot 3) = 3$ ____ $\cdot 3$ ____ $= 3$ ____

What pattern do you see when multiplying two powers with the same base?

_____

_____

Use your pattern to complete this equation: $5^2 \cdot 5^5 = 5$ ____.

Conjecture Write a general rule for the result of $a^m \cdot a^n$. _____

B Complete the following equation: $\frac{4^5}{4^3} = \frac{4 \cdot 4 \cdot 4 \cdot 4 \cdot 4}{4 \cdot 4 \cdot 4} = \frac{\overset{1}{\cancel{4}} \cdot \overset{1}{\cancel{4}} \cdot \overset{1}{\cancel{4}} \cdot 4 \cdot 4}{\underset{1}{\cancel{4}} \cdot \underset{1}{\cancel{4}} \cdot \underset{1}{\cancel{4}}} = 4 \cdot 4 = 4$ ____

What pattern do you see when dividing two powers with the same base?

_____

_____

Use your pattern to complete this equation: $\frac{6^8}{6^3} = 6$ ____.

Conjecture Write a general rule for the result of $\frac{a^m}{a^n}$. _____

C Complete the following equations:

$(5^3)^2 = (5 \cdot 5 \cdot 5)$ ____

$= (5 \cdot 5 \cdot 5) \cdot (5 \cdot 5 \cdot 5)$

$= 5$ ____

What pattern do you see when raising a power to a power?

_____

_____

Use your pattern to complete this equation: $(7^2)^4 = 7$ ____.

Conjecture Write a general rule for the result of $(a^m)^n$. _____

REFLECT

2a. Do the general rules you wrote in Parts A, B, and C apply if $a = 0$? Explain. (Assume m and n are not 0.)

PREP FOR CC.9-12.N.RN.1

3 EXAMPLE Applying Properties of Integer Exponents

Simplify each expression.

A $(5 - 2)^5 \cdot 3^{-8} + (5 + 2)^0$

$(5 - 2)^5 \cdot 3^{-8} + (5 + 2)^0$ Follow the order of operations.

$(\quad)^5 \cdot 3^{-8} + (\quad)^0$ Simplify within parentheses.

$3^{\quad} + \quad$ Use properties of exponents.

$3^{\quad} + \quad$ Simplify.

$\frac{1}{\quad} + \quad$ Add.

$1\frac{1}{\quad}$

B $(10 - 6)^3 \cdot 4^2 + (10 + 2)^2$

$(10 - 6)^3 \cdot 4^2 + (10 + 2)^2$ Follow the order of operations.

$(\quad)^3 \cdot 4^2 + (\quad)^2$ Simplify within parentheses.

$4^{\quad} + \quad$ Use properties of exponents.

$4^{\quad} + \quad$ Simplify.

$\quad + \quad$ Add.

REFLECT

3a. Describe a different method you could use to simplify each expression above that does not use properties of exponents.

PRACTICE

Find the value of each power.

1. 7^{-2} _____

2. 15^{0} _____

3. 10^{-3} _____

4. 2^{-5} _____

5. 5^{-3} _____

6. 7^{3} _____

Use properties of integers to write an equivalent expression.

7. $15^{2} \cdot 15^{-5}$ _____

8. $\frac{20^{13}}{20^{10}}$ _____

9. $\frac{14^{4}}{14^{9}}$ _____

10. $(8^{3})^{16}$ _____

11. $(12^{-5})^{3}$ _____

12. $4^{-8} \cdot 4^{-16}$ _____

13. $m \cdot m^{4}$ _____

14. $\frac{r^{9}}{r^{6}}$ _____

15. $(a^{3})^{-3}$ _____

Find the missing exponent.

16. $b^{\square} \cdot b^{2} = b^{8}$

17. $\frac{x^{5}}{x^{\square}} = x^{-2}$

18. $\left(n^{\square}\right)^{4} = n^{0}$

Simplify each expression.

19. $(2+4)^{2} + 8^{-6} \times (12-4)^{10}$ _____

20. $(3^{3})^{2} \times \left(\frac{(5-2)^{3}}{3^{4}}\right) + (10-4)^{2} \times 6^{10}$ _____

21. Error Analysis A student simplified the expression $\frac{4^{3}}{16^{3}}$ as $\frac{1}{4}$. Do you agree with the student? Justify your answer.

_____

22. Find the values of $x^{5} \cdot x^{-3}$ and $\frac{x^{5}}{x^{3}}$. What do you notice about the two values?

Explain why your results make sense based on the properties you learned in this lesson.

_____

Name _____ Class _____ Date _____

6-1

Additional Practice

Simplify.

1. $5^{-3} = \frac{1}{\_\_\_} = \frac{1}{\_\_\_}$

2. $2^{-6} = \frac{1}{\_\_\_} = \frac{1}{\_\_\_}$

3. $(-5)^{-2}$ _____

4. $-(4)^{-3}$ _____

5. -6^0 _____

6. $(7)^{-2}$ _____

Evaluate each expression for the given value(s) of the variable(s).

7. d^{-3} for $d = -2$ _____

8. a^5b^{-6} for $a = 3$ and $b = 2$ _____

9. $(b - 4)^{-2}$ for $b = 1$ _____

10. $5z^{-x}$ for $z = -3$ and $x = 2$ _____

11. $(5z)^{-x}$ for $z = -3$ and $x = 2$ _____

12. $c^{-3}(16^{-2})$ for $c = 4$ _____

Simplify.

13. t^{-4} _____

14. $3r^{-5}$ _____

15. $\frac{s^{-3}}{t^{-5}}$ _____

16. $\frac{h^0}{3}$ _____

17. $\frac{2x^{-3}y^{-2}}{z^4}$ _____

18. $\frac{4fg^{-5}}{5h^{-3}}$ _____

19. $\frac{14a^{-4}}{20bc^{-1}}$ _____

20. $\frac{a^4c^2e^0}{b^{-1}d^{-3}}$ _____

21. $\frac{-3g^{-2}hk^{-2}}{-6h^0}$ _____

22. A cooking website claims to contain 10^5 recipes. Evaluate this expression. _____

23. A ball bearing has diameter 2^{-3} inches. Evaluate this expression. _____

Problem Solving

Write the correct answer.

1. At the 2005 World Exposition in Aichi, Japan, tiny mu-chips were embedded in the admissions tickets to prevent counterfeiting. The mu-chip was developed by Hitachi in 2003. Its area is $4^2(10)^{-2}$ square millimeters. Simplify this expression.

2. Despite their name, Northern Yellow Bats are commonly found in warm, humid areas in the southeast United States. An adult has a wingspan of about 14 inches and weighs between $3(2)^{-3}$ and $3(2)^{-2}$ ounces. Simplify these expressions.

3. Saira is using the formula for the area of a circle to determine the value of π. She is using the expression Ar^{-2} where $A = 50.265$ and $r = 4$. Use a calculator to evaluate Saira's expression to find her approximation of the value of π to the nearest thousandth.

4. The volume of a freshwater tank can be expressed in terms of x, y, and z. Expressed in these terms, the volume of the tank is $x^3y^{-2}z$ liters. Determine the volume of the tank if $x = 4$, $y = 3$, and $z = 6$.

Alison has an interest in entomology, the study of insects. Her collection of insects from around the world includes the four specimens shown in the table below. Select the best answer.

Insect	Mass
Emperor Scorpion	2^{-5} kg
African Goliath Beetle	11^{-1} kg
Giant Weta	2^{-4} kg
Madagascar Hissing Cockroach	5^{-3} kg

5. Cockroaches have been found on every continent, including Antarctica. What is the mass of Alison's Madagascar Hissing Cockroach expressed as a quotient?

   A $-\frac{1}{125}$ kg C $\frac{1}{15}$ kg

   B $\frac{1}{125}$ kg D 125 kg

6. Many Giant Wetas are so heavy that they cannot jump. Which expression is another way to show the mass of the specimen in Alison's collection?

   F $-(2)4$ kg H $\frac{1}{2 \cdot 2 \cdot 2 \cdot 2}$ kg

   G $\left(\frac{1}{2}\right)^{-4}$ kg J $4\frac{1}{2}$ kg

7. Scorpions are closely related to spiders and horseshoe crabs. What is the mass of Alison's Emperor Scorpion expressed as a quotient?

   A $-\frac{1}{32}$ kg C $\frac{1}{32}$ kg

   B $\frac{1}{25}$ kg D 32 kg