Warm UP

Workbook Pg. 63
Explore A and B

Properties of Exponents

Essential Question:

How can you use properties of exponents to simplify expressions?

MCC8.EE.1:

Know and apply the properties of integer exponents to generate equivalent numerical expressions.

Exponents Song

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: $\frac{4^5}{4^3} = \frac{4 \cdot 4 \cdot 4 \cdot 4 \cdot 4}{4 \cdot 4 \cdot 4} = \frac{\cancel{4} \cdot \cancel{4} \cdot \cancel{4} \cdot 4 \cdot 4}{\cancel{4} \cdot \cancel{4} \cdot \cancel{4}} = 4 \cdot 4 = 4$☐

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:

$(5^3)^2 = (5 \cdot 5 \cdot 5)$☐

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

$= 5$☐

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: $\frac{4^5}{4^3} = \frac{4 \cdot 4 \cdot 4 \cdot 4 \cdot 4}{4 \cdot 4 \cdot 4} = \frac{\cancel{4} \cdot \cancel{4} \cdot \cancel{4} \cdot 4 \cdot 4}{\cancel{4} \cdot \cancel{4} \cdot \cancel{4}} = 4 \cdot 4 = 4$☐

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

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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 $(a^m)^n$.

TRY THIS!

Use properties of exponents to write an equivalent expression.

1a. $9^2 \cdot 9^4$ **1b.** $\frac{12^{22}}{12^4}$ **1c.** $(4^{10})^5$ **1d.** $\frac{6^9}{6^{12}}$

MCC8.EE.1

2 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.*

Properties of Exponents

MULTIPLYING POWERS WITH THE SAME BASE		
Words	**Numbers**	**Algebra**
To multiply powers with the same base, keep the base and add the exponents.	$3^5 \cdot 3^8 = 3^{5+8} = 3^{13}$	$b^m \cdot b^n = b^{m+n}$

Additional Example 1: Multiplying Powers with the Same Base

Multiply. Write the product as one power.

A. $6^6 \cdot 6^3$

6^{6+3} *Add exponents.*

6^9

B. $n^5 \cdot n^7$

n^{5+7} *Add exponents.*

n^{12}

Additional Example 1: Multiplying Powers with the Same Base Continued

Multiply. Write the product as one power.

C. $2^5 \cdot 2$

2^{5+1} *Think:* $2 = 2^1$

2^6 *Add exponents.*

D. $24^4 \cdot 24^4$

24^{4+4} *Add exponents.*

24^8

Check It Out: Example 1

Multiply. Write the product as one power.

A. $4^2 \cdot 4^4$

4^{2+4} *Add exponents.*

4^6

B. $x^2 \cdot x^3$

x^{2+3} *Add exponents.*

x^5

Properties of Exponents

Notice what occurs when you divide powers with the same base.

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

DIVIDING POWERS WITH THE SAME BASE		
Words	**Numbers**	**Algebra**
To divide powers with the same base, keep the base and subtract the exponents.	$\frac{6^9}{6^4} = 6^{9-4} = 6^5$	$\frac{b^m}{b^n} = b^{m-n}$

Additional Example 2: Dividing Powers with the Same Base

Divide. Write the quotient as one power.

A. $\dfrac{7^5}{7^3}$

7^{5-3} *Subtract exponents.*

7^2

B. $\dfrac{x^{10}}{x^9}$

x^{10-9} *Subtract exponents.*

x *Think: $x^1 = x$*

Properties of Exponents

Check It Out: Example 2

Divide. Write the product as one power.

A. $\dfrac{9^9}{9^2}$

9^{9-2} *Subtract exponents.*

9^7

B. $\dfrac{e^{10}}{e^5}$

e^{10-5} *Subtract exponents.*

e^5

Properties of Exponents

RAISING A POWER TO A POWER		
Words	Numbers	Algebra
To raise a power to a power, keep the base and multiply the exponents.	$(9^4)^5 = 9^{4 \cdot 5} = 9^{20}$	$(b^m)^n = b^{m \cdot n}$

Reading Math

$(9^4)^5$ is read as "nine to the fourth, to the fifth."

Properties of Exponents

Additional Example 3: Raising a Power to a Power

Simplify.

A. $(5^4)^2$

$(5^4)^2$

$5^{4 \cdot 2}$ *Multiply exponents.*

5^8

B. $(6^7)^9$

$(6^7)^9$

$6^{7 \cdot 9}$ *Multiply exponents.*

6^{63}

Properties of Exponents

Additional Example 3: Raising a Power to a Power

Simplify.

C. $\left(\left(\frac{2}{3}\right)^{12}\right)^{-3}$

Multiply exponents.

$\left(\frac{2}{3}\right)^{12 \cdot -3}$

$\left(\frac{2}{3}\right)^{-36}$

D. $(17^2)^{-20}$

$(17^2)^{-20}$

Multiply exponents.

$17^{2 \cdot -20}$

17^{-40}

Check It Out: Example 3

Simplify.

A. $(3^3)^4$

$(3^3)^4$

$3^{3 \cdot 4}$ *Multiply exponents.*

3^{12}

B. $(4^8)^2$

$(4^8)^2$

$4^{8 \cdot 2}$ *Multiply exponents.*

4^{16}

Properties of Exponents

Check It Out: Example 3

Simplify.

C. $\left(\left(\frac{1}{4}\right)^{11}\right)^{-2}$

Multiply exponents.

$\left(\frac{1}{4}\right)^{11 \cdot -2}$

$\left(\frac{1}{4}\right)^{-22}$

D. $(13^4)^{-10}$

$(13^4)^{-10}$

Multiply exponents.

$13^{4 \cdot -10}$

13^{-40}

PRACTICE

Complete each table.

1.

Product of Powers	Write the Factors	Write as a Single Power
$2^2 \cdot 2^4$	$(2 \cdot 2)\,(2 \cdot 2 \cdot 2 \cdot 2) = 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2 \cdot 2$	
$4^4 \cdot 4^3$		
	$(5)\,(5 \cdot 5 \cdot 5 \cdot 5) = 5 \cdot 5 \cdot 5 \cdot 5 \cdot 5$	

2.

Quotient of Powers	Write the Factors	Write as a Single Power
$\frac{3^5}{3^2}$	$\frac{3 \cdot 3 \cdot 3 \cdot \cancel{3} \cdot \cancel{3}}{\cancel{3} \cdot \cancel{3}}$	
$\frac{5^4}{5^1}$		
$\frac{4^4}{4^6}$		

Use properties of integers to write an equivalent expression.

Use properties of integers to write an equivalent expression.

3. $15^2 \cdot 15^{-5}$ _____

4. $\frac{20^{10}}{20^7}$ _____

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

6. $(8^4)^{12}$ _____

7. $(12^{-5})^3$ _____

8. $4^{-3} \cdot 4^{-21}$ _____

9. $m \cdot m^4$ _____

10. $\frac{r^5}{r^2}$ _____

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

Find the missing exponent.

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

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

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

Simplify each expression.

15. $3 \cdot (3^2)^2 + (8-4)^{-3}$ _____

16. $[(5+1)^2 \div 3] - 9^0$ _____

$(c \quad 2^2)^1$

Properties of Exponents

12. $b \cdot b = b$ 13. $\frac{x}{x} = x$ 14. $(n \quad) = n$

Simplify each expression.

15. $3 \cdot (3^2)^2 + (8-4)^{-3}$ _____

16. $[(5+1)^2 \div 3] - 9^0$ _____

17. $\frac{(6-2^2)^1}{(5-4)^6}$ _____

18. $\frac{[(4-1)^2]^0}{(2+1)^2}$ _____

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

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

Work these out in your notes.

21. There are $2^5 + 3^2$ games in half a full NBA season. How many games are in a full NBA season?

_____

22. From Earth, it is about 22^4 miles to the moon and about 9.3×10^7 to the sun. About how much farther is it to the sun than to the moon?

_____

23. **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.

_____

Homework

Text book Pg. 66
1-36 Even Only