Negative Exponents

Real-World Link

Write a ratio in simplest form that compares the number of wing beats for a butterfly to a housefly.

$$\frac{1}{100}$$

Insect	Wing Beats per Minute
house fly	10,000
small butterfly	100

Write the ratio as a fraction with an exponent in the denominator and as a decimal.

$$\frac{1}{10^2} ; \quad 0.01$$

Handwritten: $\frac{100}{10000}$ or 10^{-2}

Complete the 1st 4 rows ... dard Form

CCSS Common Core State Standards

Content Standards
8.EE.1

MP Mathematical Practices
1, 3, 4, 7

3. Complete the 1st 4 rows of the table showing the exponential and standard forms of power of 10.

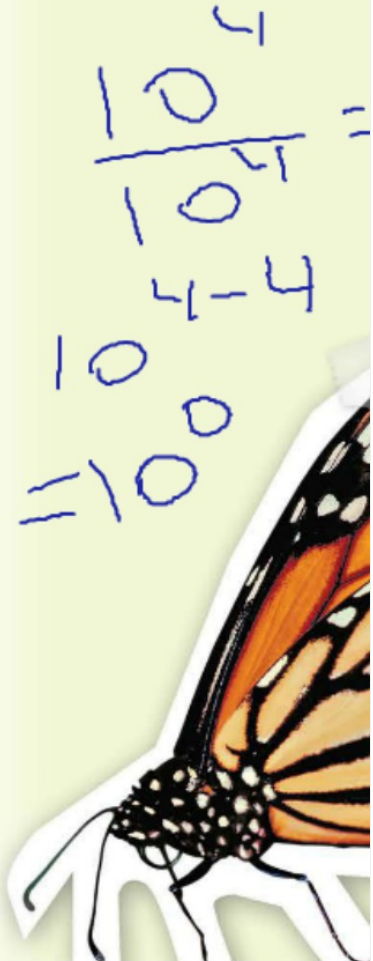4. What operation is performed when you move down the table?

division

5. What happens to the exponent?

It decreases by one.

6. Extend the table to include the next three entries.

Exponential Form	Standard Form
10^3	**1,000**
10^{2}	100.
10^1	**10.**
10^0	**1.**
10^{-1}	$\frac{1}{10}$ or **0.1**
10^{-2}	$\frac{1}{100}$ or **0.01**
10^{-3}	$\frac{1}{1,000}$ or **0.001**

$$\frac{10^4}{10^4} =$$
$$10^{4-4}$$
$$= 10^0$$
$$= 100$$

Negative powers are the result of repeated division.

Examples

Write each expression using a positive exponent.

1. 6^{-3}

$$6^{-3} = \frac{1}{6^3}$$ Definition of negative exponent

2. a^{-5}

$$a^{-5} = \frac{1}{a^5}$$ Definition of negative exponent

Got it? Do these problems to find out.

a. 7^{-2}

b. b^{-4}

c. 5^0

d. m^{-3}

Examples

Write each fra... ...g a negative exponent...

Handwritten work (left margin)

a. $\dfrac{1}{7^2}$

b. $\dfrac{1}{b^4}$

c. 1

d. $\dfrac{1}{m^3}$

na. Ask me anything.

e. 8^{-3} _____

f. 2^{-2} _____

g. c^{-5} _____

h. 3^{-3} _____

$\dfrac{1}{3^3}$

Examples

Write each fraction as an expression using a negative expone other than −1.

3. $\dfrac{1}{5^2}$

$\dfrac{1}{5^2} = 5^{-2}$ Definition of negative exponent

4. $\dfrac{1}{36}$

$\dfrac{1}{36} = \dfrac{1}{6^2}$ Definitio exponen

$= 6^{-2}$ Definitio negative

Got it?   Do these problems to find out.

e. $\dfrac{1}{8^3}$

g. $\dfrac{1}{c^5}$

4

$2 \cdot 2$

f. $\dfrac{1}{4} = \dfrac{1}{2^2}$

h. $\dfrac{1}{27}$

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Multiply and Divide with Negative Exponents

The Product of Powers and the Quotient of Powers rules can be used to multiply and divide powers with negative exponents.

Examples

Tutor

Simplify each expression.

6. $5^3 \cdot 5^{-5}$

add

$5^3 \cdot 5^{-5} = 5^{3+(-5)}$ Product of Powers

$= 5^{-2}$ Simplify.

$= \dfrac{1}{5^2}$ or $\dfrac{1}{25}$ Write using positive exponents. Simplify.

7. $\dfrac{w^{-1}}{w^{-4}}$

subtract

$\dfrac{w^{-1}}{w^{-4}} = w^{-1-(-4)}$ Quotient of Powers

$= w^{(-1)+4}$ or w^3 Subtract the exponents.

Show your work.

Handwritten notes:

$5^2 \cdot 5^3$

5^{2+3}

$(5^2)^3$

$= 5^6$

multiply!

j. $\dfrac{1}{729}$

k. $\dfrac{1}{121}$

$$5^3 \cdot 5^{-5} = 5^{3+(-5)}$$ — **Product of Powers**

$$= 5^{-2}$$ — **Simplify.**

$$= \frac{1}{5^2} \text{ or } \frac{1}{25}$$ — **Write using positive exponents. Simplify.**

Show your work.

7. $\dfrac{w^{-1}}{w^{-4}}$

Subtract

$$\frac{w^{-1}}{w^{-4}} = w^{-1-(-4)}$$ — **Quotient of Powers**

$$= w^{(-1)+4} \text{ or } w^3$$ — **Subtract the exponents.**

j. $\dfrac{1}{729}$

k. $\dfrac{1}{121}$

Got it? Do these problems to find out.

j. $3^{-8} \cdot 3^2 = 3^{-8+2} = 3^{-6} = \dfrac{1}{3^6}$

k. $\dfrac{11^2}{11^4} = 11^{2-4} = 11^{-2} = \dfrac{1}{11^2}$

l. $n^9 \cdot n^{-4} = n^{9+(-4)} = n^5$

m. $\dfrac{b^{-4}}{b^{-7}} = b^{(-4)-(-7)} = b^{-4+7} = b^3$

l. n^5

m. b^3

Lesson 5 Nega

Write each expression using a positive exponent. (Examples 1 and 2)

1. $2^{-4} = \dfrac{1}{2^4}$

2. $4^{-3} = \dfrac{1}{4^3}$

3. $a^{-4} = \dfrac{1}{a^4}$

4. $g^{-7} = \dfrac{1}{g^7}$

Show your work.

Write each fraction as an expression using a negative exponent other than −1.

(Examples 3 and 4)

5. $\dfrac{1}{3^4} = 3^{-4}$

6. $\dfrac{1}{m^5} = m^{-5}$

7. $\dfrac{1}{16} = 4^{-2}$ or 2^{-4}

8. $\dfrac{1}{49} = 7^{-2}$

9. An American green tree frog tadpole is about 0.00001 kilometer in length when it hatches. Write this decimal as a power of 10.

(Example 5) 10^{-5}

Glossary   Index   Answers: On Off

length when it hatches. Write this decimal as a power of 10.

(Example 5) 10^{-5}

Simplify. (Examples 6 and 7)

10. $3^{-3} \cdot 3^{-2} = \dfrac{1}{243}$

11. $r^{-7} \cdot r^3 = \dfrac{1}{r^4}$

12. $\dfrac{p^{-2}}{p^{-12}} = p^{10}$

13. @ **Building on the Essential Question** How are negative exponents and positive exponents related?

Sample answer: Negative exponents are the result of repeated division and positive exponents are the result of repeated multiplication. You can rewrite an expression with a negative exponent to an expression with a positive exponent by using the multiplicative inverse.

Rate Yourself!

How well do you understand understand negative exponents? Circle the image that applies.

Clear   Somewhat   Not So
         Clear   Clear

ore help, go online to

Tutor

Independent Practice

Go online for Step-by-S

Write each expression using a positive exponent. (Examples 1 and 2)

1. $7^{-10} = \dfrac{1}{7^{10}}$

2. $(-5)^{-4} = \dfrac{1}{(-5)^4}$

3. $g^{-7} = \dfrac{1}{g^7}$

4. $w^{-13} =$

Write each fraction as an expression using a negative exponent other than −1.

(Examples 3 and 4)

5. $\dfrac{1}{12^4} = 12^{-4}$

6. $\dfrac{1}{(-5)^7} = (-5)^{-7}$

7. $\dfrac{1}{125} = 5^{-3}$

8. $\dfrac{1}{1,024}$

9. The table shows different metric measurements. Write each decimal

Measurem

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9. The table shows different metric measurements. Write each decimal as a power of 10. (Example 5) $10^{-1}, 10^{-2}, 10^{-3}, 10^{-6}$

Measurement	Va
Decimeter	0.1
Centimeter	0.01
Millimeter	0.00
Micrometer	0.00

10. STEM An atom is a small unit of matter. A small atom measures about 0.0000000001 meter. Write the decimal as a power of 10. (Example 5)

10^{-10}

Simplify. (Examples 6 and 7)

11. $2^{-3} \cdot 2^{-4} = \dfrac{1}{128}$

12. $s^{-5} \cdot s^{-2} = \dfrac{1}{s^7}$

13 $y^{-1} \cdot y^4 = y^3$

14. $(3a)(a^{-3}) = \dfrac{3}{a}$

15. $\dfrac{3^{-1}}{3^{-5}} = 81$

16. $\dfrac{a^{-4}}{a^{-6}} = a^2$

17. $\dfrac{y^{-6}}{y^{-10}} = y^4$

18. $\dfrac{z^{-4}}{z^{-8}} = z^4$

19 STEM The mass of a molecule of penicillin is 10^{-18} kilogram and the mass of a molecule of insulin is 10^{-23} kilogram. How many times greater is the mass of a molecule of penicillin than the mass of a molecule of insulin?

10^5 or 100,000 times

20. **MP Justify Conclusions** A common flea that is 2^{-4} inch long can jump about 2^3 inches high. About how many times its body size can a flea jump? Explain your reasoning.

2^7 or 128 times; $2^3 \div 2^{-4} = 2^{3-(-4)}$ or 2^7

H.O.T. Problems Higher Order Thinking

21. **MP Identify Structure** Without evaluating, order 11^{-3}, 11^2, and 11^0 from least to greatest. Explain your reasoning.

11^{-3}, 11^0, 11^2; Sample answer: The exponents in order from least to greatest are −3, 0, 2.

22. **MP** **Identify Structure** Write an expression with a negative exponent that has a value between 0 and $\frac{1}{2}$.

Sample answer: 3^{-2}, $3^{-2} = \frac{1}{3^2}$ or $\frac{1}{9}$

23. **MP** **Persevere with Problems** Select several fractions between 0 and 1. Find the value of each fraction after it is raised to the -1 power. Explain the relationship between the -1 power and the original fraction.

Sample answer: $\left(\frac{1}{2}\right)^{-1} = 2$, $\left(\frac{34}{43}\right)^{-1} = \frac{43}{34}$, $\left(\frac{56}{65}\right)^{-1} = \left(\frac{65}{56}\right)$; When you raise a fraction to the -1 power, it is the same as finding the reciprocal of the fraction.

24. **MP** **Reason Abstractly** For each power, write an equivalent multiplication expression with two factors. The first factor should have a positive exponent and the second factor should have a negative exponent. **Sample answers are given.**

a. $10^4 = \underline{10^6 \cdot 10^{-2}}$

b. $8^2 = \underline{8^5 \cdot 8^{-3}}$

c. $x^7 = \underline{x^{12} \cdot x^{-5}}$