

NAME

DATE

PERIOD

Unit 7, Lesson 5: Negative Exponents with Powers of 10

Let's see what happens when exponents are negative.

5.1: Number Talk: What's That Exponent?

Solve each equation mentally.

$$\frac{100}{1} = 10^x$$

$$\frac{100}{x} = 10^1$$

$$\frac{x}{100} = 10^0$$

$$\frac{100}{1000} = 10^x$$

NAME _____

DATE _____

PERIOD _____

5.2: Negative Exponent Table

Complete the table to explore what negative exponents mean.

		← ·10	← ·10	← ·10	← ·10	← ·10	← ·10
using exponents	10^3	10^2	10^1				
as a decimal	1000.0			1.0		0.01	
as a fraction		$\frac{100}{1}$		$\frac{1}{1}$			$\frac{1}{1000}$
		← ·?	← ·?	← ·?	← ·?	← ·?	← ·?

- As you move toward the left, each number is being multiplied by 10. What is the multiplier as you move right?
- How does each of these multipliers affect the placement of the decimal?
- Use the patterns you found in the table to write 10^{-7} as a fraction.
- Use the patterns you found in the table to write 10^{-5} as a decimal.
- Write $\frac{1}{100,000,000}$ using a single exponent.
- Use the patterns in the table to write 10^{-n} as a fraction.

NAME _____

DATE _____

PERIOD _____

5.3: Follow the Exponent Rules

1. a. Match the expressions that describe repeated multiplication in the same way:

$(10^2)^3$	$\frac{1}{(10 \cdot 10)} \cdot \frac{1}{(10 \cdot 10)} \cdot \frac{1}{(10 \cdot 10)}$
$(10^2)^{-3}$	$\left(\frac{1}{10} \cdot \frac{1}{10}\right) \left(\frac{1}{10} \cdot \frac{1}{10}\right) \left(\frac{1}{10} \cdot \frac{1}{10}\right)$
$(10^{-2})^3$	$\frac{1}{\frac{1}{10} \cdot \frac{1}{10}} \cdot \frac{1}{\frac{1}{10} \cdot \frac{1}{10}} \cdot \frac{1}{\frac{1}{10} \cdot \frac{1}{10}}$
$(10^{-2})^{-3}$	$(10 \cdot 10)(10 \cdot 10)(10 \cdot 10)$

- b. Write $(10^2)^{-3}$ as a power of 10 with a single exponent. Be prepared to explain your reasoning.

2. a. Match the expressions that describe repeated multiplication in the same way:

$\frac{10^2}{10^5}$	$\frac{\frac{1}{10} \cdot \frac{1}{10}}{\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}}$
$\frac{10^2}{10^{-5}}$	$\frac{10 \cdot 10}{10 \cdot 10 \cdot 10 \cdot 10 \cdot 10}$
$\frac{10^{-2}}{10^5}$	$\frac{\frac{1}{10} \cdot \frac{1}{10}}{10 \cdot 10 \cdot 10 \cdot 10 \cdot 10}$
$\frac{10^{-2}}{10^{-5}}$	$\frac{10 \cdot 10}{\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}}$

- b. Write $\frac{10^{-2}}{10^{-5}}$ as a power of 10 with a single exponent. Be prepared to explain your reasoning.

NAME _____

DATE _____

PERIOD _____

3. a. Match the expressions that describe repeated multiplication in the same way:

$10^4 \cdot 10^3$	$(10 \cdot 10 \cdot 10 \cdot 10) \cdot \left(\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}\right)$
$10^4 \cdot 10^{-3}$	$\left(\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}\right) \cdot \left(\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}\right)$
$10^{-4} \cdot 10^3$	$\left(\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}\right) \cdot (10 \cdot 10 \cdot 10)$
$10^{-4} \cdot 10^{-3}$	$(10 \cdot 10 \cdot 10 \cdot 10) \cdot (10 \cdot 10 \cdot 10)$

- b. Write $10^{-4} \cdot 10^3$ as a power of 10 with a single exponent. Be prepared to explain your reasoning.

Are you ready for more?

Priya, Jada, Han, and Diego are playing a game. They stand in a circle in this order and take turns playing a game.

Priya says, SAFE. Jada, standing to Priya's left, says, OUT and leaves the circle. Han is next: he says, SAFE. Then Diego says, OUT and leaves the circle. At this point, only Priya and Han are left. They continue to alternate. Priya says, SAFE. Han says, OUT and leaves the circle. Priya is the only person left, so she is the winner.

Priya says, "I knew I'd be the only one left, since I went first."

- Record this game on paper a few times with different numbers of players. Does the person who starts always win?
- Try to find as many numbers as you can where the person who starts always wins. What patterns do you notice?

NAME _____

DATE _____

PERIOD _____

Lesson 5 Summary

When we multiply a positive power of 10 by $\frac{1}{10}$, the exponent *decreases* by 1:

$$10^8 \cdot \frac{1}{10} = 10^7$$

This is true for *any* positive power of 10. We can reason in a similar way that multiplying by 2 factors that are $\frac{1}{10}$ *decreases* the exponent by 2:

$$\left(\frac{1}{10}\right)^2 \cdot 10^8 = 10^6$$

That means we can extend the rules to use negative exponents if we make $10^{-2} = \left(\frac{1}{10}\right)^2$. Just as 10^2 is two factors that are 10, we have that 10^{-2} is two factors that are $\frac{1}{10}$. More generally, the exponent rules we have developed are true for *any* integers n and m if we make

$$10^{-n} = \left(\frac{1}{10}\right)^n = \frac{1}{10^n}$$

Here is an example of extending the rule $\frac{10^n}{10^m} = 10^{n-m}$ to use negative exponents:

$$\frac{10^3}{10^5} = 10^{3-5} = 10^{-2}$$

To see why, notice that

$$\frac{10^3}{10^5} = \frac{10^3}{10^3 \cdot 10^2} = \frac{10^3}{10^3} \cdot \frac{1}{10^2} = \frac{1}{10^2}$$

which is equal to 10^{-2} .

Here is an example of extending the rule $(10^m)^n = 10^{m \cdot n}$ to use negative exponents:

$$(10^{-2})^3 = 10^{(-2)(3)} = 10^{-6}$$

To see why, notice that $10^{-2} = \frac{1}{10} \cdot \frac{1}{10}$. This means that

$$(10^{-2})^3 = \left(\frac{1}{10} \cdot \frac{1}{10}\right)^3 = \left(\frac{1}{10} \cdot \frac{1}{10}\right) \cdot \left(\frac{1}{10} \cdot \frac{1}{10}\right) \cdot \left(\frac{1}{10} \cdot \frac{1}{10}\right) = \frac{1}{10^6} = 10^{-6}$$

NAME _____

DATE _____

PERIOD _____

Unit 7, Lesson 5: Negative Exponents with Powers of 10

1. Write with a single exponent: (ex: $\frac{1}{10} \cdot \frac{1}{10} = 10^{-2}$)

a. $\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}$

b. $\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10}$

c. $(\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10})^2$

d. $(\frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10})^3$

e. $(10 \cdot 10 \cdot 10)^{-2}$

2. Write each expression as a single power of 10.

a. $10^{-3} \cdot 10^{-2}$

b. $10^4 \cdot 10^{-1}$

c. $\frac{10^5}{10^7}$

d. $(10^{-4})^5$

e. $10^{-3} \cdot 10^2$

f. $\frac{10^{-9}}{10^5}$

3. Select **all** of the following that are equivalent to $\frac{1}{10,000}$:

A. $(10,000)^{-1}$

B. $(-10,000)$

C. $(100)^{-2}$

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

E. $(-10)^2$

NAME _____

DATE _____

PERIOD _____

4. Match each equation to the situation it describes. Explain what the constant of proportionality means in each equation.

Equations:

Situations:

A. $y = 3x$

1. A dump truck is hauling loads of dirt to a construction site. After 20 loads, there are 70 square feet of dirt.

B. $\frac{1}{2}x = y$

2. I am making a water and salt mixture that has 2 cups of salt for every 6 cups of water.

C. $y = 3.5x$

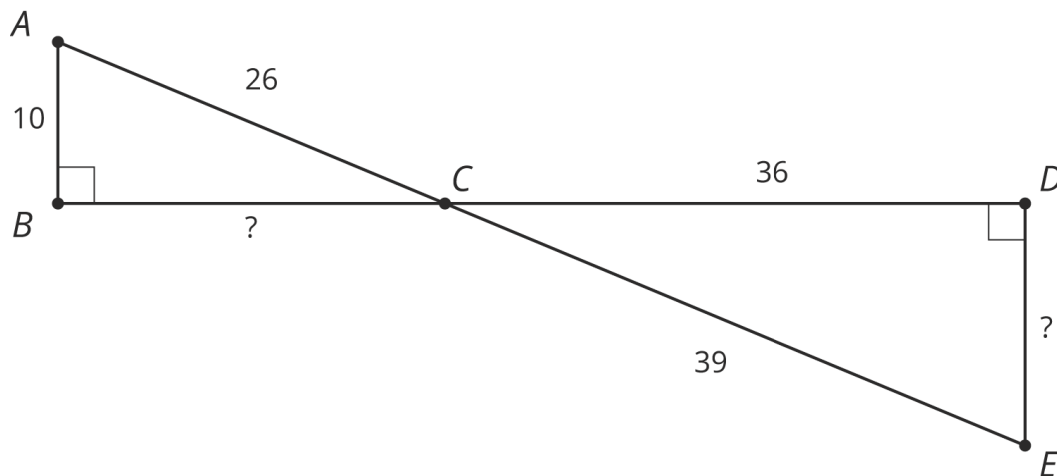
3. A store has a "4 for \$10" sale on hats.

D. $y = \frac{5}{2}x$

4. For every 48 cookies I bake, my students get 24.

(from Unit 3, Lesson 2)

5. a. Explain why triangle ABC is similar to EDC .



b. Find the missing side lengths.

(from Unit 2, Lesson 8)