Negative Exponents with Powers of 10

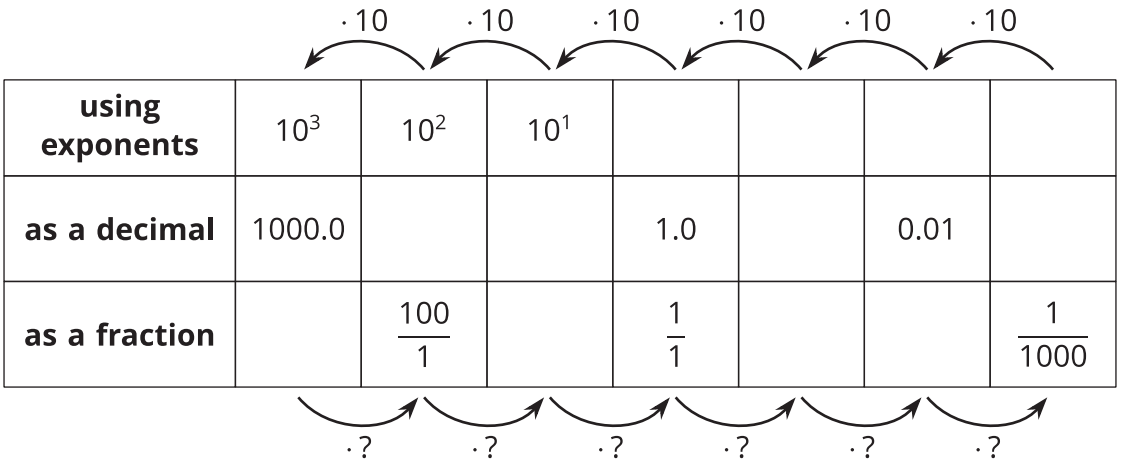
Let's see what happens when exponents are negative.

4.1 Math Talk: What's That Exponent?

Find the value of x mentally.

- $\frac{100}{1} = 10^x$
- $\frac{100}{x} = 10^1$
- $\frac{x}{100} = 10^0$
- $\frac{100}{1{,}000} = 10^x$

4.2 Negative Exponent Table



1. Complete the table to explore what negative exponents mean.

2. As you move toward the left, each number is being multiplied by 10. What is the multiplier as you move right?

3. How does a multiplier of 10 affect the exponent? How does it affect the value of the decimal and fraction?

4. How does the other multiplier affect the exponent? How does it affect the value of the decimal and fraction?

5. Use the patterns you found in the table to write 10^{-7} as a fraction.

6. Use the patterns you found in the table to write 10^{-5} as a decimal.

7. Write $\frac{1}{100,000,000}$ using a single exponent.

8. Use the patterns in the table to write 10^{-n} as a fraction.

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4.3 Follow the Exponent Rules

1. a. Match each exponential expression with an equivalent multiplication expression:

$(10^2)^3$

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

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

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

$\frac{1}{(10 \cdot 10)} \cdot \frac{1}{(10 \cdot 10)} \cdot \frac{1}{(10 \cdot 10)}$
$\left(\frac{1}{10} \cdot \frac{1}{10}\right)\left(\frac{1}{10} \cdot \frac{1}{10}\right)\left(\frac{1}{10} \cdot \frac{1}{10}\right)$
$\frac{1}{\frac{1}{10} \cdot \frac{1}{10}} \cdot \frac{1}{\frac{1}{10} \cdot \frac{1}{10}} \cdot \frac{1}{\frac{1}{10} \cdot \frac{1}{10}}$
$(10 \cdot 10)(10 \cdot 10)(10 \cdot 10)$

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

2. a. Match each exponential expression with an equivalent multiplication expression:

$\frac{10^2}{10^5}$

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

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

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

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

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

3. a. Match each exponential expression with an equivalent multiplication expression:

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

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 stand in a circle 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."

1. Record this game on paper a few times with different numbers of players. Does the person who starts always win?

2. Try to find as many numbers as you can where the person who starts always wins. What patterns do you notice?

Lesson 4 Summary

In this lesson, we observed that when we multiply a positive power of 10 by $\frac{1}{10}$, the exponent decreases by 1. For example, $10^8 \cdot \frac{1}{10} = 10^7$. This is true for any power of 10.

By using the rule $10^n \cdot 10^m = 10^{n+m}$ with this example, we see that: $10^8 \cdot 10^{-1} = 10^7$.

Notice that for the exponent rules we have developed to work, then $\frac{1}{10}$ must equal 10^{-1}.

Rule	Example showing how it works
$10^{-n} = \frac{1}{10^n}$	$10^{-3} = \frac{1}{10} \cdot \frac{1}{10} \cdot \frac{1}{10} = \frac{1}{10^3}$ three factors that are one tenth