So Many Zeros!

Overview

Students will explore standard and scientific notation representations of numbers. Students will also discuss the need for different representations of very large or small numbers, and they will see real-world examples of these representations.

Math Concepts

- patterns
- multiple representations of numbers
- scientific notation
- exponents

Materials

- TI-30XS MultiView™
- pencil
- paper

Activity

Begin with a discussion about large numbers.

What is the largest possible number you can imagine? A million? A trillion? More?

Obviously, answers will vary. Now talk about writing these large digits.

Try to write the largest number you can imagine. How much space does that take up? Is it difficult to keep track of the number of digits?

Let's review powers of 10.

10^1	= 10	= 10
10^2	= 10 • 10	= 100
10^3	= 10 • 10 • 10	= 1,000
10^4	= 10 • 10 • 10 • 10	= 10,000
10^5	= 10 • 10 • 10 • 10 • 10	= 100,000

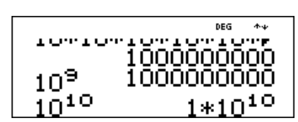
Do you see a pattern between the exponent and the number of zeros in the answer? What about a larger number like 10^{13}? It would take plenty of time and space to find that answer by hand! There is an easier way. It's called scientific notation.

Scientific notation allows us to write a very large number as a rational number between 1 and 10, multiplied by a power of 10. Example: Writing the number 398,000,000,000,000,000 is the same as 398 • 1,000,000,000,000,000. Using the pattern above, that's the same as 398 • 10^{15}. Now, using scientific notation, that would be 3.98 • 10^{17}.

Show the general rule.

Follow these steps:

1. Input 10 ς 10 ς ⋯ until you have 10 × 10 × 10 nine times.
2. Now press <.
3. Try 10 Γ 9 and press < again (and get the same answer, but much faster).
4. Now try 10 Γ 10.
5. Notice how the answer is given differently? That's scientific notation:



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In general, the process is as follows: To write 398,000,000,000,000,000 in scientific notation, place the decimal after the first digit, and then count the number of digits to the right to determine the exponent.

3.98~~*,000,000,000,000,000*~~
base

To the right of the decimal, there are 17 places,

so the answer is $3.98 \cdot 10^{17}$.

Remind students to count the *total* number of places to the right of the decimal, not just the zeros.

Follow these steps:

1. To go from scientific to standard notation, press 3.89, then X.
2. Enter the exponent, 17.
3. Press π ∃ < to select standard (normal) notation.
4. Press % Θ to return to home screen.
5. Press < to display your entry in standard notation.

Note: The TI-30XS MultiView will display standard notation only through $\times 10^9$. For anything larger, the calculator will automatically convert to scientific notation.

First, let's try these with pencil and paper.

1. *45,000,000*
2. *1,790,000,000,000,000*
3. *90,082,890,000,000*

Now, let's use the TI-30XS MultiView on the same examples.

Show how scientific notation also works for very small numbers.

Follow these steps:

1. Enter 45000000.
2. Press π.
3. Press ∃ ∀ < to select scientific notation.
4. Press % Θ to return to home screen.
5. Press < to display your entry in scientific notation.

So far, we've looked at very large numbers. But aren't extremely small numbers also difficult to work with because of the large number of digits? Take, for example, 0.000000000000067.

Again using the rules for scientific notation, we can place the decimal after the first digit. But this time, we'll count the number of digits to the left *of the decimal.*

0~~*.00000000000000*~~***6.7***
base

To the left of the decimal, there are 14 places. But since we're considering digits to the left, *we have to think in terms of negative exponents. So, our answer is* $6.7 \cdot 10^{-14}$.

Follow these steps:

1. Press .000000000000067.
2. Press π.
3. Press ∃ ∀ < to select scientific notation.
4. Press % Θ to return to home screen.
5. Press < to display your entry in scientific notation.

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Try these examples, first with pencil and paper, then using your TI-30XS MultiView.

1. 0.0000089   2. 0.000000000007104

3. 0.000000000000000008002

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Name ____________________

Date ____________________

Directions: In real life, we encounter many very small or large numbers. Below are several such instances. Use what you have learned about scientific notation and the TI-30XS MultiView™ to find the missing forms of these numbers.

Real-life examples	**Word notation**	**Standard notation**	**Scientific notation**
Population of Earth	6 billion, 174 million		
Speed of light		300,000,000 m/s	
Diameter of a grain of sand		0.0024 in.	
Raindrops in a storm cloud	6 1/2 trillion		
Cells in the human body			$1.2 \bullet 10^{14}$
Stars in the Milky Way		230,000,000,000,000	
Length of a dust mite			$1.36 \bullet 10^{-1}$ mm
Width of a human hair		0.0018 cm	
Weight of a ladybug	21 thousandths of a gram		
Distance from Pluto to Neptune		1,320,000,000 km	
Distance from Neptune to the Sun			$4.55 \bullet 10^{9}$ km

Bonus: If Neptune is closer to the Sun than Pluto, how far is Pluto from the Sun? Express your answer in both standard and scientific notation.

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Answer Key

Real-life examples	Word notation	Standard notation	Scientific notation
Population of Earth	6 billion, 174 million	6,174,000,000	$6.174 \bullet 10^{9}$
Speed of light	300 million m/s	300,000,000 m/s	$3.0 \bullet 10^{8}$ m/s
Diameter of a grain of sand	24 ten-thousandths of an inch	0.0024 in.	$2.4 \bullet 10^{-3}$ in.
Raindrops in a storm cloud	6 1/2 trillion	6,500,000,000,000	$6.5 \bullet 10^{12}$
Cells in the human body	12 trillion	12,000,000,000,000	$1.2 \bullet 10^{13}$
Stars in the Milky Way	230 trillion, 80 billion	230,080,000,000,000	$2.3008 \bullet 10^{14}$
Length of a dust mite	136 thousandths of a mm	0.136 mm	$1.36 \bullet 10^{-1}$ mm
Width of a human hair	108 hundred-thousandths of a cm	0.00108 cm	$1.08 \bullet 10^{-3}$ cm
Weight of a ladybug	21 thousandths of a gram	0.021 g	$2.1 \bullet 10^{-2}$ g
Distance from Pluto to Neptune	1 billion, 320 million km	1,320,000,000 km	$1.32 \bullet 10^{9}$ km
Distance from Neptune to the Sun	4 billion, 550 million km	4,550,000,000 km	$4.55 \bullet 10^{9}$ km

Bonus: If Neptune is closer to the Sun than Pluto, how far is Pluto from the Sun? Express your answer in both standard and scientific notation.

Since Neptune is closer, you have to add the Sun-to-Neptune distance to the Neptune-to-Pluto distance. (Many students will subtract.)

1,320,000,000 km + 4,550,000,000 km = 5,870,000,000 km

$1.32 \bullet 10^{9}$ km + $4.55 \bullet 10^{9}$ km = $5.87 \bullet 10^{9}$ km