WORDS TO KNOW

standard form

scientific notation

coefficient

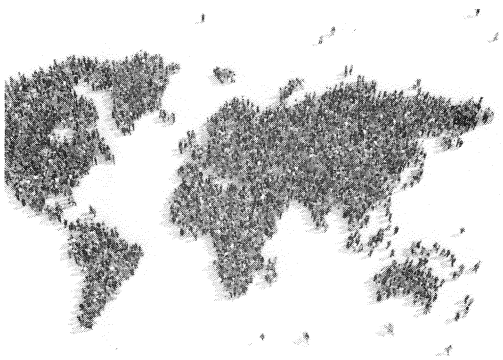
Lesson 5

UNDERSTANDING SCIENTIFIC NOTATION

NY-8.EE.3

INTRODUCTION

Real-World Connection



The population of the world is about seven billion people. Written out, the number is 7,000,000,000. The mass of a dust particle is 753 trillionths of a kilogram, or 0.000000000753 kg. Scientists prefer to write numbers that are very large or very small in scientific notation. Scientific notation is a shorter way of writing numbers. Let's practice the skills in the **Guided Instruction** and **Independent Practice** and see what these numbers look like in scientific notation at the end of the lesson!

What I Am Going to Learn

- How to write numbers using scientific notation
- How to compare two numbers in scientific notation and express how many times larger one is than the other.

What I May Already Know

- I know how to write and evaluate expressions using exponents.
- I know that a digit in one place represents 10 times as much as it represents in the place to its right, and $\frac{1}{10}$ of what it represents in the place to its left.
- I know the patterns in the number of zeros of the product when multiplying a number by powers of 10 and the patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10.

Vocabulary in Action

Standard form is how you have written numbers.

- For very large or small numbers, these numbers can be long.
- For example: 3,400,000,000,000 or 0.000000056 are written in **standard form**.

Numbers written in **scientific notation** are in the form $a \times 10^n$ and are a shorter way to write numbers.

- The first part, a, is the **coefficient**. This number appears before the multiplication sign. It is a number greater than or equal to 1 and less than 10, so $1 \leq a < 10$.
- The coefficient is being multiplied by the second part, which is the power of ten. The exponent for the power of 10, n, tells you how many places the decimal point moves in the coefficient, a. When converting a number to scientific notation, use a negative exponent if you need to move the decimal to the right, and a positive exponent if you need to move the decimal to the left.

EXAMPLE

The United Service Organization (USO) helps 4,900,000 Active Duty, Guard, and Reserve military families. Write 4,900,000 in scientific notation.

Step One Move the decimal point from its current location so that there is only one non-zero digit to the left of it.

4.900000

Step Two Count the number of places and the direction that the decimal point was moved.

It was moved from 4,900,000 to 4 900000.

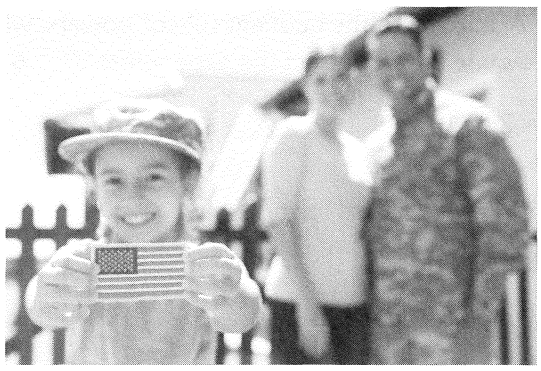
The decimal point moved 6 places to the left. Moving to the left indicates a positive exponent in the power of ten.

Step Three Write the number in scientific notation with a coefficient and a power of ten.

4.9 is the coefficient between 1 and 10.

The power of ten is 10^6 because you moved the decimal point 6 places to the left. 4,900,000 is 10^6 times the value of 4.9.

In scientific notation, $4{,}900{,}000 = 4.9 \times 10^6$.



THINK ABOUT IT

Will a number written in scientific notation ever have any zeros? Explain with an example.

Writing very small numbers in scientific notation is a similar process. However, the exponent in the power of ten will be negative.

EXAMPLE

Write 0.00015 in scientific notation.

Step One Move the decimal point from its current location so that there is only one non-zero digit to the left of it.

00001.5

Step Two Count the number of places and the direction that the decimal point was moved.

It was moved from 0 00015 to 00001 5.

The decimal point moved 4 places to the right. Moving to the right indicates a negative exponent on the power of ten.

Step Three Write the number in scientific notation with a coefficient and a power of ten.

1.5 is the coefficient between 1 and 10.

The power of ten is 10^{-4} because you moved the decimal point 4 places to the right. 0.00015 is 10^{-4} times as much as 1.5.

In scientific notation, $0.00015 = 1.5 \times 10^{-4}$.

SKETCH IT

Draw a table, or thinking map, showing what can be measured using scientific notation with positive exponents, and what can be measured using scientific notation with negative exponents.

Numbers in scientific notation can be compared using division.

EXAMPLE

How many times as large is 9×10^{10} than 3×10^{6}?

Step One Divide. Set up a fraction.

$$\frac{9 \times 10^{10}}{3 \times 10^{6}}$$

Step Two Divide the coefficients: $9 \div 3 = 3$.

Step Three According to the quotient rule of powers, when dividing powers that have the same base, subtract the exponents: $10 - 6 = 4$.

$$\frac{9 \times 10^{10}}{3 \times 10^{6}} = 3 \times 10^{4}$$

Step Four Write in standard form.

$3 \times 10^{4} = 30{,}000$

So, 9×10^{10} is 30,000 times as large as 3×10^{6}.

GUIDED INSTRUCTION

1. Write the number 21,000,000 in scientific notation.

Step One Move the decimal point from its current location so that the coefficient will be between 1 and 10.

21,000,000 to 2.1

Step Two Count the number of places and the direction that the decimal point was moved.

The decimal was moved 7 places to the left, So, the exponent is a positive 7.

Step Three Write the number in scientific notation with a coefficient and a power of ten.

$21{,}000{,}000 = 2.1 \times 10^{7}$

TIPS AND HINTS

Always remember to think about which direction you are moving the decimal point because it makes a big difference in the meaning of the exponent.

2. Write the number 0.00098 in scientific notation.

Step One Move the decimal point from its current location so that the coefficient will be between 1 and 10.

0.00098 to 9.8

Step Two Count the number of places and the direction that the decimal point was moved.

The decimal was moved 4 places to the right, So, the exponent is -4.

Step Three Write the number in scientific notation with a coefficient and a power of ten.

$0.00098 = \boxed{} \times 10^{-4}$

3. How many times as much is 2×10^6 than 1×10^3?

Step One Divide 2×10^6 by 1×10^3. Create a fraction.

$$\frac{2 \times 10^6}{1 \times 10^3}$$

Step Two Divide the coefficients.

$2 \div 1 = 2$

Step Three Divide the powers of 10 by subtracting the exponents.

$10^6 \div 10^3 = 10^{(6-3)} = 10^3$

Step Four Write in standard form.

$2 \times 10^3 = 2{,}000$

2×10^6 is [ ] times the value of 1×10^3.

4. How many times as much is 6×10^{12} than 2×10^9?

Ⓐ 30

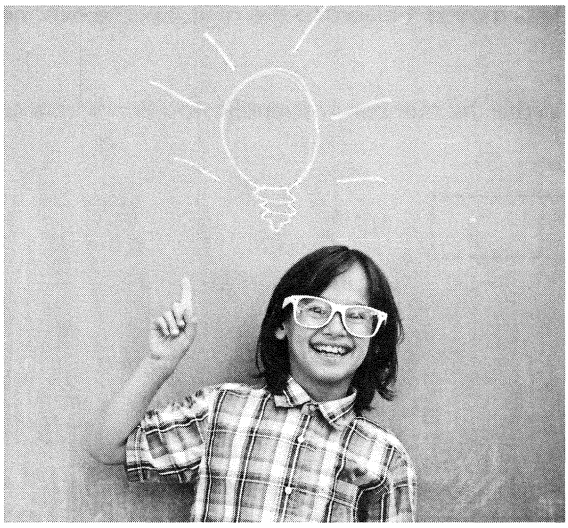
Ⓑ 300

Ⓒ 3,000

Ⓓ 30,000

THINK ABOUT IT

What word in this question makes you think you will divide these two numbers in scientific notation?



Learning Together

Work with a partner to create a poster with two sides. On one side, show the steps involved in converting a large number into scientific notation with a positive exponent. On the other side, show the steps involved in converting a very small number into scientific notation with a negative exponent. On your poster, identify the use of standard form, scientific notation, and a coefficient.

Large Number = positive exponent	Small Number = negative exponent

How Am I Doing?

What questions do you have?

Think about a coefficient that is multiplied by the power of 10. Describe the pattern between these three pieces: the exponent, how many places the decimal moves, and how many times larger or smaller the coefficient is.

In what year were you born? Express your answer in scientific notation.

Circle the sign that shows how you are doing with the skill.

I am stuck.

I almost have it.

I understand the skill.

INDEPENDENT PRACTICE 1

1 What is 0.0000072 written in scientific notation?

A 72

B 7.2×10^{-6}

C 7.2×10^{-8}

D 0.72×10^{6}

THINK ABOUT IT

What have you learned about exponents when you move the decimal to the right in the coefficient?

2 The amount of water on the surface of Earth is approximately 140 million square miles. What is this number in scientific notation?

A 1.4×10^{6}

B 14×10^{6}

C 1.4×10^{8}

D 14×10^{8}

SKETCH IT

Write the number in words out in standard form. Having this visual will make it easier to convert the number to scientific notation.

3 The weight of a full-grown elephant ranges from 5,000 pounds to 14,000 pounds. Which of these expressions represents the range of weights, in pounds, in scientific notation?

A 5.0×10^{4} to 1.4×10^{4}

B 5.0×10^{3} to 14×10^{3}

C 5.0×10^{3} to 1.4×10^{4}

D 50×10^{3} to 1.4×10^{5}

TIPS AND HINTS

Remember that the coefficient must be a number between 1 and 10, and the exponent represents the number of places and direction that the decimal point was moved.

4 Suppose the U.S. government had 5×10^9 new social security numbers that could be assigned, and each of the 50 states was allocated the same number of new social security numbers to assign to new citizens. How many new social security numbers would be allocated to each state? Leave your answer in scientific notation.

Explain your answer.

SHARE IT

The U.S. uses social security numbers for citizen identification. Do you think all countries have these numbers? If not, what type of a system, if any, do other countries use?

INDEPENDENT PRACTICE 2

1 Which shows the number 6,350 in scientific notation?

A 6×10^3

B 6.35×10^1

C 6.35×10^3

D 635×10^1

2 Which shows the number "eighty-seven thousandths" in scientific notation?

A 8.7×10^{-3}

B 8.7×10^{-2}

C 8.7×10^3

D 87×10^3

3 Which number is written correctly in scientific notation?

A 8.0×10^3

B 0.6×10^6

C 0.71×10^3

D 93×10^{-10}

4 The number 5×10^8 is how many times as much as 1×10^2?

A 50

B 5,000,000

C 5,000,000,000

D 50,000.000,000

5 Which number is greater than 25,300?

A 2.6×10^4

B 3.45×10^3

C 2.13×10^3

D 2.5×10^4

6 The diameter of a helium atom is 6.2×10^{-7} nm. The diameter of a chlorine atom is 1.54×10^{-6} nm. What is the difference in diameter of the two atoms?

A 0.0092 nm

B 0.00000000000095 nm

C 0.00000092 nm

D 0.00000216 nm

7 Thomas made some mistakes when he calculated the approximate total number of red, black, or blond hairs on Earth. Which of the following statements is true?

NUMBER OF HAIRS ON EARTH

Hair color	Human population with specific hair color	Average strands of hair per person	Total number of strands of hair in the world
Red	1.4×10^8	100,000	1.4×10^{13}
Black	5.88×10^9	90,000	5.292×10^{12}
Blond	2.1×10^8	110,000	2.31×10^{13}

Which of the following statements is true?

A The numbers of red and black hairs are correct.

B The numbers of black and blond hairs are correct.

C Only the number of black hairs is correct.

D The numbers of red and blond hairs are correct.

8 The table below shows four expressions in random-size order.

Order	Expression
?	1×10^{-7}
?	1.13×10^{-6}
?	1.01×10^{-6}
?	1.2×10^{-2}

With 1 being the least and 4 being the greatest, number the four expressions from least to greatest.

Answer 1. _____, 2. _____, 3. _____, 4. _____

Explain your answer.

9 Mary stated that 2.01×10^6 is less than 4.8×10^4 because 2.01 is less than 4.8. What was Mary's mistake? Use what you know about scientific notation.

Explain your answer.

EXIT TICKET

NY-8.EE.3

Now that you have mastered writing and comparing numbers in scientific notation, let's solve the problem in the **Real-World Connection**.

The population of the world is about seven billion people. Written out, the number is 7,000,000,000. The mass of a dust particle is 753 trillionths of a kg, or 0.000000000753 kg. How are these numbers written in scientific notation?