Key Concepts

Lesson 9

Scientific Notation

Objective Teach students to write very large and small numbers in scientific notation and to compare and order numbers written in scientific notation.

Note to the Teacher *Scientific notation is a useful topic for many applications. It also provides a great opportunity to reinforce students' understanding of place value in terms of powers of ten.*

Very Large and Very Small Numbers

Introduce some very large and very small numbers. A few examples are listed.

- The mass of the planet Pluto is roughly 12,900,000,000,000,000,000,000 kilograms.
- The number of molecules in a cubic centimeter of oxygen at standard temperature and pressure is about 602,000,000,000,000,000,000,000.
- A typical cell membrane is about 0.00000001 meter thick.
- A large virus has a diameter of roughly 0.0000001 meter.

Each of the numbers shown above contains many zeros. Thus, it may be difficult to read and compare them. However, there is a notation that can be used to express all of the zeros in a simple, easy to read form. Consider the following examples.

Example 1

7,000,000,000 (seven billion) $= 7 \times$ (one billion)
$= 7 \times 10^9$ *One billion is equal to 10^9.*

Notice how few symbols are required to write 7×10^9 compared to 7,000,000.

Example 2

13,000,000 (thirteen million) $= 13 \times$ (one million)
$= 13 \times 10^6$ *One million is equal to 10^6.*
$= 1.3 \times 10^7$ *1.3 is one tenth of 13.*

Example 3

0.0000056 (fifty-six ten-millionths)

$= 5 \times$ (one millionth) $+ 6 \times$ (one ten-millionth)

$= 5 \times \frac{1}{1{,}000{,}000} + 6 \times \frac{1}{10{,}000{,}000}$

$= 5 \times \frac{1}{10^6} + 6 \times \frac{1}{10^7}$ *1,000,000 = 10^6 and 10,000,000 = 10^7*

$= 5 \times 10^{-6} + 6 \times 10^{-7}$ *Laws of Negative Exponents*

$= (5 + 6 \times 10^{-1}) \times 10^{-6}$ *Factor 10^{-6}.*

$= 5.6 \times 10^{-6}$

Key Idea	Every nonzero number can be written as a number greater than or equal to one and less than ten times a power of ten.

Have students work through some exercises.

Exercises

Write each number as a number greater than or equal to one and less than ten times a power of ten.

1. 12,300
1.23×10^4

2. 0.00257
2.57×10^{-3}

3. 1,324,000,000
1.324×10^9

Definition of Scientific Notation	A number that is written as a number between 1 and 10 times a power of ten is said to be written in scientific notation.

All of the following numbers are written in scientific notation.

$$1.2 \times 10^6 \qquad 2.4 \times 10^{-5} \qquad 5.8 \times 10^{18}$$

The following numbers are *not* written in scientific notation because the number in front of the multiplication sign is not between 1 and 10.

$$12.5 \times 10^{12} \qquad 0.15 \times 10^{11} \qquad 235 \times 10^{-13}$$

Writing Numbers in Scientific Notation

There are two steps to writing a large positive number in scientific notation. Consider the number 1,649,000,000. The first step is to move the decimal point to the right of the leftmost digit. Remove all of the zeros on the far right.

$$1{,}649{,}000{,}000 \rightarrow 1.\underbrace{649000000} = 1.649$$

The second step is to multiply this number by a power of 10. To find the power of 10, count the number of places you moved the decimal point.

$$1{,}649{,}000{,}000 \rightarrow 1.\underbrace{649000000}_{9 \text{ places}} \times 10^{?}$$

So, in scientific notation, 1,649,000,000 is written 1.649×10^9.

Example 4 **Write 3,587,000,000,000 in scientific notation.**

Solution $3{,}587{,}000{,}000{,}000 = 3.587 \times 10^{12}$ *Move the decimal point 12 places to the left. Multiply by 10^{12}.*

To write numbers less than 1 in scientific notation, there is a similar method. Consider the number 0.0000387. The first step is to move the decimal point to the right of the first nonzero digit. Remove all of the zeros on the far left.

$$0.0000387 = \underbrace{00003}.87 = 3.87$$

The second step is to multiply this number by a power of 10. To find the power of 10, count the number of places you moved the decimal point. Then use the negative of that number as the exponent of 10.

$$0.0000387 = \underbrace{00003}_{5 \text{ places}}.87$$

In this case, the decimal point was moved 5 places. So, -5 will be used as the exponent of ten. In scientific notation, 0.0000387 is written 3.87×10^{-5}.

Example 5 **Write 0.000000634 in scientific notation.**

Solution $0.000000634 = 6.34 \times 10^{-7}$ *Move the decimal point 7 places to the right. Multiply by 10^{-7}.*

Comparing and Ordering Numbers in Scientific Notation

It is easy to compare two numbers that are given in scientific notation.

Key Idea	To compare two numbers given in scientific notation, first compare the exponents. The one with the greater exponent will be greater. If the exponent is the same, compare the two numbers that are being multiplied by comparing their decimals.

Example 6 **Compare 6.23×10^{14} and 8.912×10^{12}.**

Solution Since the exponent in the first number is greater than the exponent in the second number, 6.23×10^{14} is greater than 8.912×10^{12}.

Example 7 **Which is greater, 5.15×10^{-4} or 6.35×10^{-5}?**

Solution Since -4 is greater than -5, 5.15×10^{-4} is greater than 6.35×10^{-5}.

Example 8 **Compare 3.28×10^{17} and 4.25×10^{17}.**

Solution The exponents are both 17. So, we need to compare the numbers that are being multiplied. Since 4.25 is greater than 3.28, 4.25×10^{17} is greater than 3.28×10^{17}.