What is scientific notation?

Scientific notation is a way we can easily write very large numbers or very small numbers. It is typically used by scientists.

The number **123,000,000,000** in scientific notation is written as $\mathbf{1.23 \cdot 10^{11}}$

$$1.23 \cdot 10^{11}$$
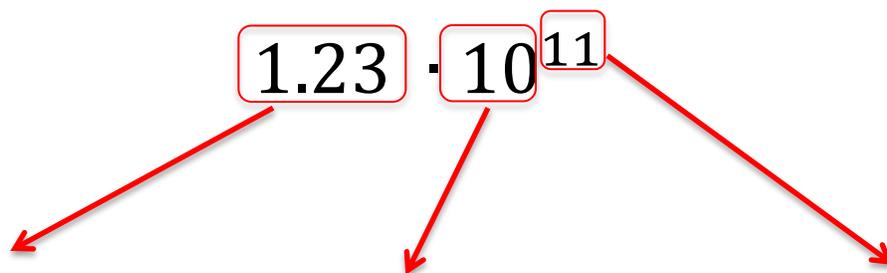
The first number is called the *coefficient*. It must be between 1 and 10.

The second number is called the *base*. When using scientific notation, the base must always be 10.

The third number is called the *exponent* or *power of ten*. This number will always be an integer.

The first number, or coefficient, must be between 1 and 10. For the following problems, determine if the number is written in correct scientific notation.

A. $42.6 \cdot 10^8$ B. $0.96 \cdot 10^2$ C. $5.09 \cdot 10^{-5}$

Here's an example of the process for writing a number in scientific notation:
480,000,000

Place the decimal point so the coefficient is between 1 and 10.
4.80000000

Count how many places the decimal point "moved".

Use the number of digits for your exponent (or power of ten).

$$\mathbf{4.8 \cdot 10^8}$$

This same process can be used for very small numbers. Here's an example:

$$0.000000145$$

place the decimal point so the coefficient is between 1 and 10.

$$00000001.45$$

Count the digits from the new decimal point to the old decimal point.

Use the number of digits for your exponent (or power of ten).

$$1.45 \cdot 10^{-7}$$

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What we can take away from the process:

• When the number is 10 or greater, the decimal point has to move **to the left**, and the power of 10 is **positive**.

• When the number is smaller than 1, the decimal point has to move **to the right**, so the power of 10 is **negative**.

Complete the following practice problems to show what you know about scientific notation. Remember your answer is only in correct scientific notation if the coefficient is between 1 and 10.

1.   5400000   2.   0.000006

3.   0.009   4.   60

5.   2000000   6.   0.000216

7.   48900   8.   0.0042

Here's an example of the process for writing a number in regular notation:

$$3.6 \cdot 10^{12}$$

Since the exponent is positive, move the decimal point to the right. The exponent of 12 means to move the decimal point 12 places.

3.6

Fill in the decimal places with zeros.

Our number is **3,600,000,000,000**

This same process can be used for very small numbers. Here's an example:

$$4.2 \cdot 10^{-7}$$

Since the exponent is negative, move the decimal point to the left. The exponent of 7 means to move the decimal point 7 places.

4.2

Fill in the decimal places with zeros.

Our number is **0.00000042**

Complete the following practice problems to show what you know about scientific notation. Convert each number written in scientific notation to regular notation.

1. $7.1 \cdot 10^3$

2. $1.5 \cdot 10^{-6}$

3. $2.66 \cdot 10^7$

4. $8.3 \cdot 10^4$

5. $1.71 \cdot 10^{-5}$

6. $3.6 \cdot 10^{-7}$

What if the coefficient is *not* between 1 and 10?

If the coefficient is not between 1 and 10, we will have to rewrite our number in correct scientific notation. Here's an example:

$$14.3 \cdot 10^5$$

Our coefficient is not between 1 and 10.
So we will need to move our decimal to make it between one and ten.

Once we have moved our decimal, we need to update our exponent.

For each place you move the decimal to the left, **add** one to the exponent.

For each place you move the decimal to the right, **subtract** one from the exponent.

In the example above, we moved the decimal one place to the left, so we should add one to the exponent.

$$1.43 \cdot 10^{5+1} = 1.43 \cdot 10^6$$

Practice a few examples on your own.

1. $21.2 \cdot 10^3$ 4. $0.59 \cdot 10^5$

2. $11.5 \cdot 10^4$ 5. $78 \cdot 10^{-3}$

3. $0.46 \cdot 10^7$ 6. $0.612 \cdot 10^{-4}$

Operations with Scientific Notation

Like any number, you can add, subtract, multiply and divide numbers written in scientific notation. However, there are some rules you have to follow.

Addition and Subtraction

In order to add or subtract numbers in scientific notation, you must first make sure that each number has the same exponent.

We CAN add or subtract $3.4 \cdot 10^5$ and $1.1 \cdot 10^5$ because they have the same exponent of 5.

We CANNOT add or subtract $2.9 \cdot 10^2$ and $7.3 \cdot 10^3$ because they have different exponents (2 and 3).

If you have two numbers with different exponents, you will have to rewrite the numbers so they have the same exponent. Let's try this with the example from above.

$$2.9 \cdot 10^2 \qquad 7.3 \cdot 10^3$$

First, decide which number you're going to change.
(In most cases, the easier choice will be to change the smaller exponent.)
Then, follow the rules for moving decimals and changing coefficients.

$$2.9 \cdot 10^{2+1} \qquad 7.3 \cdot 10^3$$

(move the decimal one place to the left, add one to the exponent)

$$.29 \cdot 10^3 \qquad 7.3 \cdot 10^3$$

Once the numbers have the same exponent, you can add or subtract them!

Multiplication and Division

To multiply or divide numbers in scientific notation,

1. Group the coefficients together and the powers of 10 together.
2. Multiply or divide the coefficients.
3. Add or subtract the exponents (based on the exponent rule).
4. Make sure your final answer is in correct scientific notation.

Ex. $9 \cdot 10^3 \times 5 \cdot 10^2$

1. Group the coefficients together and the powers of 10 together

   $(9 \cdot 5) \cdot (10^3 \cdot 10^2) \quad =$

2. Multiply or divide the coefficients.

   $(9 \cdot 5) = 45$

3. Add or subtract the exponents (based on the exponent rule).

   $(10^3 \cdot 10^2) = 10^{3+2} = 10^5$

4. Make sure your final answer is in correct scientific notation.

   $45 \cdot 10^5$ NOT in correct scientific notation. $\boxed{9 \cdot 10^3 \times 5 \cdot 10^2 = 4.5 \cdot 10^6}$
   $4.5 \cdot 10^6$

Ex. $12 \cdot 10^7 \div 3 \cdot 10^5$

1. Group the coefficients together and the powers of 10 together

   $(12 \div 3) \cdot (10^7 \div 10^5)$

2. Multiply or divide the coefficients.

   $(12 \div 3) = 4$

3. Add or subtract the exponents (based on the exponent rule).

   $(10^7 \div 10^5) = 10^{7-5} = 10^2$

4. Make sure your final answer is in correct scientific notation.

   $4 \cdot 10^2$ is in correct scientific notation. $\boxed{12 \cdot 10^7 \div 3 \cdot 10^5 = 4 \cdot 10^2}$

Practice a few on your own:

1. $2 \cdot 10^4 \times 8 \cdot 10^1$

4. $7.1 \cdot 10^6 \div 8.2 \cdot 10^1$

2. $3.48 \cdot 10^3 \times 9.8 \cdot 10^4$

5. $8.42 \cdot 10^3 \div 5 \cdot 10^2$

3. $2.32 \cdot 10^6 \times 4 \cdot 10^{-3}$

6. $4.7 \cdot 10^3 \div 3.11 \cdot 10^2$

To add or subtract numbers in scientific notation,

    1. Make sure the numbers have the <u>same</u> exponent.
    2. Add or subtract the coefficients.
    3. Keep the same base and exponent.
    4. Make sure your final answer is in correct scientific notation.

Ex. $6.4 \cdot 10^8 - 2.9 \cdot 10^7$

1. Make sure the numbers have the same exponent.

    $6.4 \cdot 10^8 - 2.9 \cdot 10^7$ Different exponents need to be changed.
    $6.4 \cdot 10^8 - .29 \cdot 10^8$

2. Add or subtract the coefficients.

    $6.4 - .29 = 6.11$

3. Keep the same base and exponent.

    $6.11 \cdot 10^8$

4. Make sure your final answer is in correct scientific notation.

    $6.11 \cdot 10^8$ is in correct scientific notation.

    $6.4 \cdot 10^8 - 2.9 \cdot 10^7 = 6.11 \cdot 10^8$

Practice a few on your own:

1. $8.94 \cdot 10^3 + 8 \cdot 10^4$

4. $6 \cdot 10^6 + 8.2 \cdot 10^8$

2. $7.46 \cdot 10^7 - 5.23 \cdot 10^6$

5. $4.2 \cdot 10^2 + 6.1 \cdot 10^1$

3. $8.76 \cdot 10^3 - 6.35 \cdot 10^4$

6. $8.8 \cdot 10^7 - 7.7 \cdot 10^6$

Comparing Numbers in Scientific Notation

To compare numbers in scientific notation, first compare the exponents.
   ◆ The number with the greater exponent is greater.

   $3.12 \cdot 10^6$ is greater than $5.34 \cdot 10^4$ because 6 is greater than 4.

   ◆ If the exponents are the same, compare the coefficients.

   $4.31 \cdot 10^5$ is greater than $2.18 \cdot 10^5$ because 4.31 is greater than 2.18.

1. Place the following numbers in order from least to greatest.

   $7.8 \cdot 10^6$ $5.1 \cdot 10^4$ $1.25 \cdot 10^5$ $4.09 \cdot 10^4$

2. Order the following numbers from greatest to least.

   $5 \cdot 10^3$ $3.2 \cdot 10^8$ $1.2 \cdot 10^8$ $7 \cdot 10^5$

3. Order the following numbers from greatest to least.

   $5 \cdot 10^{-3}$ $3.2 \cdot 10^{-8}$ $1.2 \cdot 10^{-8}$ $7 \cdot 10^{-5}$

4. Order the following from least to greatest.

   $6.8 \cdot 10^{6}$ $6 \cdot 10^{6}$ $6.6 \cdot 10^{6}$ $6.1 \cdot 10^{6}$

5. Order the following from least to greatest.

   $6.8 \cdot 10^{-6}$ $6 \cdot 10^{-6}$ $6.6 \cdot 10^{-6}$ $6.1 \cdot 10^{-6}$