SCIENTIFIC NOTATION

Why do we need scientific notation?

When writing out a very large number such as three hundred and eighty billion, or a very small number such as thirty-two millionths, we encounter two problems. The first is that very large or very small numbers take considerable time and space to write out; the second problem is that it is difficult to write so many digits accurately. Both these problems can be solved by using a shorthand method for writing such numbers called scientific notation.

What is scientific notation?

Let us begin with our two examples, rewritten in scientific notation form:

$$380,000,000,000 = 3.8 \times 10^{11}$$
$$0.0000032 = 3.2 \times 10^{-6}$$

When a number is written in scientific notation form, it is expressed as a product of two numbers. The first number is the coefficient, which is a number with only one non-zero digit to the left of the decimal. The second number is 10 raised to an integer (whole number) power; this integer may be negative.

Coefficient ⟶ 3.25×10^{-6} ⟵ Exponent (also called Power)

How do we write numbers in scientific notation form?

Remember:

10^1	=	10	10^{-1} = $\frac{1}{10}$	=	0.1
10^2	=	100	10^{-2} = $\frac{1}{100}$	=	0.01
10^3	=	1000	10^{-3} = $\frac{1}{1000}$	=	0.001

So if we have: 0.0073

we can rewrite it as: 7.3×0.001
which is equal to: 7.3×10^{-3} (multiplying a number by 10 raised to a negative power makes the number smaller).

Another way to do this is to first find the decimal point, then count how many places you would have to move it over in order for there to be one, and only one, digit to the left of the decimal point.

How to write 0.0073 in scientific notation: 0 . 0 0 7 3   = 7.3×10^{-3}

In this case, the decimal point would have to be moved over 3 places to the right. If we have to move the decimal point to the right, then the exponent on the "10" is negative.

This works for large numbers as well:

How to write 685,000,000 in scientific notation: 6 8 5, 0 0 0, 0 0 0 . = 6.85×10^8

In this case, the decimal point would have to be moved over 8 places to the left. If we have to move the decimal point to the left, then the exponent on the "10" is positive.

When using a scientific calculator, make sure you understand how to enter numbers in scientific notation into your calculator. For example, many calculators use "7.3E-3" to represent "7.3 x 10^{-3}". However, each calculator is different, so read the instructions for your calculator! If you are working with very large or very small numbers and don't use scientific notation properly, you may get erroneous results.

How do we work with numbers in scientific notation form?

1. <u>Addition and subtraction</u>. In addition and subtraction, all numbers are converted to the same power of 10 and the digit numbers are added or subtracted. For example:

$$(3.22 \times 10^{-3}) + (1.7 \times 10^{-4})$$
$$= (3.22 \times 10^{-3}) + (0.17 \times 10^{-3})$$
$$= 3.39 \times 10^{-3}$$

When working with numbers in scientific notation form, we sometimes have to do one more step to convert the answer into scientific notation form. For example:

$$(8.9 \times 10^{-2}) + (9.2 \times 10^{-2}) = 18.1 \times 10^{-2} = 1.81 \times 10^{-1}$$

but the answer must only have one digit to the left of the decimal point, so 18.1×10^{-2} in scientific notation is 1.81×10^{-1}

2. <u>Multiplication and division</u>. When multiplying and dividing numbers in scientific notation form, you must remember the following rules.

When multiplying two numbers which are powers of the same base, <u>add</u> the powers.
$$10^3 \times 10^7 = 10^{3+7} = 10^{10}$$

When dividing two numbers which are powers of the same base, <u>subtract</u> the powers.
$$10^5 \div 10^2 = 10^{5-2} = 10^3$$

Multiplication:
When multiplying numbers in scientific notation, the coefficients are multiplied in the usual way and the powers are added as shown above.
$$(4.2 \times 10^3) \times (1.6 \times 10^5) = [(4.2) \times (1.6)] \times 10^{(3+5)}$$
$$= 6.72 \times 10^8$$

Division:
When dividing numbers in scientific notation, the coefficients are divided and the powers subtracted.

$$\frac{6.1 \times 10^7}{2.1 \times 10^2} = \frac{6.1}{2.1} \times 10^{(7-2)} = 2.9 \times 10^5$$

3. <u>Raising scientific notation numbers to a power</u>.
When a number in scientific notation is raised to a power, e.g., $(1.6 \times 10^3)^2$, raise each of the terms inside the parenthesis to the power of 2:

$$(1.6 \times 10^3)^2 = (1.6)^2 \times (10^3)^2 = 2.56 \times 10^{3 \times 2} = 2.56 \times 10^6$$

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