

Lesson 00-A2-Powers of Ten – Scientific Notation

When dealing with numbers that are very large (something like the mass of the Earth = $M_E = 5,975,000,000,000,000,000,000$ kg) or very small (like, say, the mass of an electron = $m_e = 0.000\ 000\ 000\ 000\ 000\ 000\ 000\ 000\ 911$ kg) we use scientific notation to keep the numbers more compact on the page. Scientific notation also fits in well with our rules for writing exponents. We write numbers in terms of powers of 10.

$$10^0 = 1$$

$$10^1 = 10$$

$$10^2 = 100$$

$$10^3 = 1\ 000$$

$$10^4 = 10\ 000$$

$$10^5 = 100\ 000$$

$$10^6 = 1\ 000\ 000$$

$$10^7 = 10\ 000\ 000$$

$$10^0 = 1$$

$$10^{-1} = 1/10 = 0.1$$

$$10^{-2} = 1/100 = 0.01$$

$$10^{-3} = 1/1\ 000 = 0.001$$

$$10^{-4} = 1/10\ 000 = 0.000\ 1$$

$$10^{-5} = 1/100\ 000 = 0.000\ 01$$

$$10^{-6} = 1/1\ 000\ 000 = 0.000\ 001$$

$$10^{-7} = 1/10\ 000\ 000 = 0.000\ 000\ 1$$

and so forth. When writing numbers in scientific notation, generally you should write them in the following form.

$$n.nnnn \times 10^m$$

There should be one non-zero digit ahead of the decimal point in proper scientific notation. There are plenty of times when you will have a legitimate need to move the decimal point to other positions, however.

For numbers greater than one this works easily enough. Take the number of seconds in a year (31 557 600 s) as an example. Always begin by writing the number with an explicit decimal point (31 557 600.0). In proper scientific notation the decimal point should appear immediately following the 3. Count the number of decimal places the decimal point must be moved. In this example the decimal point must be moved 7 places to the left. The exponent is therefore +7 and the scientific notation for this number is

$$3.155\ 760\ 0 \times 10^7\ \text{s}$$

The mass of the Earth mentioned earlier is 5.975×10^{24} kg.

For numbers between zero and one the process is essentially the same. Count the number of decimal places the decimal point must be moved to the right. For the mass of an electron the decimal point must be moved 31 places to the right of its original position to just after the 9. The exponent is therefore –31 and in scientific notation the mass of the electron is

$$9.11 \times 10^{-31}\ \text{kg}$$

Calculator notation is $9.11\text{E}-31$ or $9.11\text{e}-31$, where **E** or **e** is shorthand for “ $\times 10$ ”.

When processing numbers in scientific notation by hand, process the numerical terms and the exponential terms separately.

$$(2.34 \times 10^{-8})(8.16 \times 10^2) = (2.34 \times 8.16)(10^{-8} \times 10^2) = 19.1 \times 10^{-8+2} = 1.91 \times 10^{-5}$$

On a TI scientific calculator you will find an **EE** key that makes it easy to enter numbers in scientific notation. The calculator will keep track of the decimal point location for you and may display the answer in a wide variety of formats depending on your choice of internal settings.

On a TI calculator the calculation above might be keyed into the calculator as follows:
(Note that the key labeled (-) is used to enter negative signs in expressions, not for subtraction.)

2.34 **EE** (-) 8 \times 8.16 **EE** 2 **ENTER**

1.909440 E-5

There are several pitfalls that you may encounter when using a calculator. One of the most insidious is a mis-keyed entry. Always read your input before you press the **ENTER** key. This is just a good habit to get into. Even one keystroke out the 15 keystrokes required to complete this calculation will ruin it. There are many keystrokes ahead of you and mis-keys are easy to make. Don't get tripped up by a simple typing error. Check all your entries before you start the calculation.