Scientific Notation - A Review

Scientific Notation - Why do we need it ?

We know that electrical and electronic quantities can be range from very large to very small. We need a way to handle these cumbersome numbers, especially when we are working with them in mathematical equations.

The advantages of this notation are:

1) Very large and small numbers are much more condensed when expressed in this form.

2) Numbers in this form can be used in a computations with far greater ease.

The following is a short discussion of scientific notation. The notation is based ***on powers of 10***. The general format looks like this: $N \ X \ 10^x$

where N = number greater than 1 but less than 10
x = exponent of 10.

Here is how it works:

Consider the regular number 247 000.

1) Move the decimal point so that the number is between 1 and 10

2.47000.

2) Count the number of places that you moved the decimal point to the ***left***. (In this case, 5 places)

2.47000
5 4 3 2 1

3) The number of places becomes the ***exponent.***

247000 = 2.47 X 10^{5}

Consider the regular number 0.00369

1) Move the decimal point so that the number is between 1 and 10

0.003.69

2) Count the number of places that you moved the decimal point to the ***right***. (In this case, 3 places)

0 003.69
1 2 3

3) The number of places becomes the negative ***exponent.***

0.00369 = 3.69 X 10^{-3}

When you move the decimal to the ***left*** - the exponent is ***positive***.

When you move the decimal to the ***right*** - the exponent is ***negative***.

Common Power of Ten Multipliers

$1\,000\,000 = 10^6$	$0.000001 = 10^{-6}$
$100\,000 = 10^5$	$0.00001 = 10^{-5}$
$10\,000 = 10^4$	$0.0001 = 10^{-4}$
$1\,000 = 10^3$	$0.001 = 10^{-3}$
$100 = 10^2$	$0.01 = 10^{-2}$
$10 = 10^1$	$0.1 = 10^{-1}$
$1 = 10^0$	$1 = 10^0$

Multiplication and Division Using Scientific Notation

To multiply numbers

1) multiply their base numbers
2) add their exponents.

e.g. $(1.2 \text{ X } 10^3)(1.5 \text{ X } 10^4) = (1.2)(1.5) \text{ X } 10^{(3+4)} = 1.8 \text{ X } 10^7$

To divide numbers

1) divide their base numbers
2) subtract the exponents in the denominator from those in the numerator

e.g.

$$\frac{4.5 \text{ X } 10^2}{3.0 \text{ X } 10^{-2}} = \frac{4.5}{3} \text{ X } 10^{2-(-2)} = 1.5 \text{ X } 10^4$$

Addition and Subtraction Using Scientific Notation

To add or subtract numbers

1) adjust all numbers to the same power of 10
2) add or subtract the ordinary numbers in the usual way

e.g. **Using 10^2 as the common power of 10** $(3.25 \text{ X } 10^2) + (5 \text{ X } 10^3)$

Adjust both numbers to the same power $= (3.25 \text{ X } 10^2) + (50 \text{ X } 10^2)$

Add the ordinary numbers in the usual way $= 53.25 \text{ X } 10^2$

Put the answer in proper scientific notation $= 5.325 \text{ X } 10^3$

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e.g. **Using 10^3 as the common power of 10** $(3.25 \text{ X } 10^2) + (5 \text{ X } 10^3)$

Adjust both numbers to the same power $= (.325 \text{ X } 10^3) + (5 \text{ X } 10^3)$

Add the ordinary numbers in the usual way $= 5.325 \text{ X } 10^3$

Powers

Raising a number to a power is a form of multiplication (or division if the exponent is negative)

e.g.

$$(2 \text{ X } 10^3)^2 = (2 \text{ X } 10^3)(2 \text{ X } 10^3) = 4 \text{ X } 10^6$$

Integer fractional powers represent roots.

e.g.

$$4^{1/2} = \sqrt{4} = 2 \qquad 27^{1/3} = \sqrt[3]{27} = 3$$

One Final Note

If power of ten numbers are written with ***one digit to the left of the decimal place***, they are said to be in ***scientific notation***.
Thus **$2.47 \text{ X } 10^5$** is in scientific notation, while **$24.7 \text{ X } 10^4$** and **$0.247 \text{ X } 10^6$** are not.

Engineering Notation

Engineering notation uses prefixes that are used to represent certain powers of ten. The table below shows the common prefixes that we use.

A quantity such as **0.034 V** (Volts) can be expressed as **3.4×10^{-2}** V but it is preferable to express it as **34×10^{-3}** V or **34 mV** (millivolts).

It is usual to select a prefix that results in a base number that is between 0.1 and 999.

Engineering Prefixes

Power of Ten	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

Rounding Numbers

When multiplying or dividing approximate values the operands should be examined to determine which operand has the least number of significant digits. This operand determines how many digits the result should be rounded to. Consider the multiplication of the two numbers below.

$$4.65 \text{ X } 4.5 = 20.925 \longrightarrow 21$$

The number 4.5 has only two significant digits; therefore the result should be rounded to two significant digits. If the first number has a variance of 0.005 and the second number a variance of 0.05. The absolute minimum value of the result is calculated below.

$$4.645 \text{ X } 4.45 = 20.67025$$

The absolute maximum value of the result is calculated below.

$$4.655 \text{ X } 4.55 = 21.18025$$

Example Problem

First calculate the result of the following operations and then round the result to the correct number of significant digits.

OPERATION		RESULT	ROUNDED RESULT
1.3647 + 0.05	=	______________	______________
00315 - 1.85 + 1211.1	=	______________	______________
1.3647 * 0.05	=	______________	______________
51.3 9.857	=	______________	______________