LESSON 1: QUANTITIES AND UNITS

QUANTITIES: A quantity is defined as anything that can be measured, such as length, mass, time, temperature or force.

Base quantities: they are those that are independent of the others. Base quantities are LENGTH, MASS and TIME

Derived quantities: they are those that are defined as a function of basic quantities. For example speed and density:

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S = distance travelled   t = time taken   v = speed

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d = density   m = mass   V = volume

What of these quantities are basic or derived?

SI BASE UNITS

Base quantity		SI base unit	
Name of base quantity	**Symbol**	**Name of SI base unit**	**Symbol**
length	*l, x, r,* etc.	metre	m
mass	*m*	kilogram	kg
time, duration	*t*	second	s
electric current	*I, i*	ampere	A
thermodynamic temperature	*T*	kelvin	K
amount of substance	*n*	mole	mol
luminous intensity	I_v	candela	cd

DERIVED QUANTITIES AND UNITS. SI

QUANTITY	UNIT	SYMBOL
SPEED	Metre per second	m/s
Acceleration	Metre per square second	m/s^2
Force	Newton	N
Energy	July	J
Power	Vat	W
Area	square metre	m^2
Volume	cubic metre	m^3
Pressure	Pascal	Pa
Density	Kilogram per cubic metre	kg/m^3

MULTIPLES AND SUBMULTIPLES OF THE INTERNATIONAL SYSTEM SI

Factor of multiplication	prefixe	simbol	value
10^{12}	**tera**	T	1 000 000 000 000
10^{9}	**giga**	G	1 000 000 000
10^{6}	**mega**	M	1 000 000
10^{3}	**chilo**	k	1 000
10^{2}	**hecto**	h	100
10^{1}	**deka**	da	10
10^{-1}	**deci**	d	0.1
10^{-2}	**centi**	c	0.01
10^{-3}	**milli**	m	0.001
10^{-6}	**micro**	µ	0.000 001
10^{-9}	**nano**	n	0.000 000 001
10^{-12}	**pico**	p	0.000 000 000 001

SCIENTIFIC NOTATION: WHAT IS IT?

Astronomers deal with quantities ranging from the truly microcosmic to the macrocosmic. It is very inconvenient to always have to write out the age of the universe as 15,000,000,000 years or the distance to the Sun as 149,600,000,000 meters. To save effort, **powers-of-ten** notation is used. Using powers-of-ten notation, the age of the universe is 1.5 x 10^{10} years and the distance to the Sun is 1.496 x 10^{11} meters. For example, **$10 = 10^1$**; the exponent tells you how many times to multiply by 10. As another example, **$10^{-2} = 1/100 = 0{,}01$**; in this case the exponent is negative, so it tells you how many times to divide by 10. The only trick is to remember that **$10^0 = 1$**.

> **The general form** of a number in scientific notation is $\boldsymbol{a} \mathbf{\ x\ 10}^{\boldsymbol{n}}$, where *a* must be between 1 and 10, and *n* must be an integer. (Thus, for example, these are not in scientific notation: 34 x 10^5; 4.8 x $10^{0.5}$.).

The use of scientific notation has several advantages, even for use outside of the sciences:

> Scientific notation makes the expression of very large or very small numbers much simpler. For example, it is easier to express the U.S. federal debt as \$3 x 10^{12} rather than as \$3,000,000,000,000.

CONVERTING FROM "NORMAL" TO SCIENTIFIC NOTATION

Place the decimal point after the first non-zero digit, and count the number of places the decimal point has moved. If the decimal place has moved to the *left* then multiply by a positive power of 10; to the right will result in a negative power of 10.

> *Example:* To write 3040 in scientific notation we must move the decimal point 3 places to the left, so it becomes 3.04 x 10^3.
>
> *Example:* To write 0.00012 in scientific notation we must move the decimal point 4 places to the right: 1.2 x 10^{-4}.

CONVERTING FROM SCIENTIFIC NOTATION TO "NORMAL"

If the power of 10 is positive, then move the decimal point to the right; if it is negative, then move it to the left.

> *Example:* Convert 4.01 x 10^2. We move the decimal point two places to the right making 401.
>
> *Example:* Convert 5.7 x 10^{-3}. We move the decimal point three places to the left making 0.0057.

WORKING WITH SCIENTIFIC NOTATION: ADDITION, MULTIPLICATION, ...

Addition and Subtraction

When adding or subtracting numbers in scientific notation, their powers of 10 must be equal. If the powers are *not* equal, then you must first convert the numbers so that they all have the same power of 10.

Example: $(6.7 \times 10^9) + (4.2 \times 10^9) = (6.7 + 4.2) \times 10^9 = 10.9 \times 10^9 = 1.09 \times 10^{10}$. (Note that the last step is necessary in order to put the answer in scientific notation.)

Example: $(4 \times 10^8) - (3 \times 10^6) = (4 \times 10^8) - (0.03 \times 10^8) = (4 - 0.03) \times 10^8 = 3.97 \times 10^8$.

Multiplication and Division

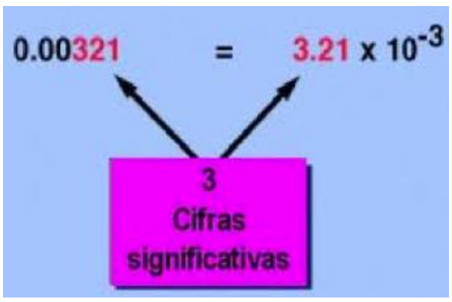
It is very easy to multiply or divide just by rearranging so that the powers of 10 are multiplied together.

Example: $(6 \times 10^2) \times (4 \times 10^{-5}) = (6 \times 4) \times (10^2 \times 10^{-5}) = 24 \times 10^{2-5} = 24 \times 10^{-3} = 2.4 \times 10^{-2}$. (Note that the last step is necessary in order to put the answer in scientific notation.)

PROPERTIES OF POWERS OF TEN:

SIGNIFICANT FIGURES

Numbers should be given only to the accuracy that they are known with certainty, or to the extent that they are important to the topic at hand. For example, your doctor may say that you weigh 130 pounds, when in fact at that instant you might weigh 130.16479 pounds. The discrepancy is unimportant.



$\_\_ , \_\_ \_\_ . 10^{\text{exponent}}$

TO APROXIMATE

Count the number of figures you want and look at the next one, if it is 5 or greater, the last digit is increased one unit; if it is 4 or less, the last digit is left the same.

WITHOUT ZEROS BEHIND AND BEFORE. SCIENTIFIC NOTATION

• $10^0 = 1$ • $10^1 = 10$ • $10^2 = 100$ • $10^3 = 1\ 000$ • $10^4 = 10\ 000$ • $10^5 = 100\ 000$ • $10^6 = 1\ 000\ 000$ • $10^7 = 10\ 000\ 000$ • $10^8 = 100\ 000\ 000$ • $10^9 = 1\ 000\ 000\ 000$ • $10^{10} = 10\ 000\ 000\ 000$ • $10^{20} = 100\ 000\ 000\ 000\ 000\ 000\ 000$ • $10^{30} =$ 1 000 000 000 000 000 000 000 000 000 000 • $10^{-1} = 1/10 = 0{,}1$ • $10^{-2} = 1/100 = 0{,}01$ • $10^{-3} = 1/1\ 000 = 0{,}001$ • $10^{-9} = 1/1\ 000\ 000\ 000 = 0{,}000\ 000\ 001$	FOR EXAMPLE: 156 234 000 000 000 000 000 000 000 000= $1{,}56234\times10^{29} \approx 1{,}56 \times 10^{29}$ Electron mass: 0,000 000 000 000 000 000 000 000 000 000 910 939 kg $=9{,}10939\times10^{-31}$kg $\approx 9{,}11 \times 10^{-31}$ kg