Physical Quantities and Units

Base Quantities and Units

- We use several **<u>physical quantities</u>** such as length, time, mass, weight, density, pressure, energy, potential difference, etc and their associated units in Physics.
- Some of these physical quantities are called **<u>Base Quantities</u>** and the others are called **<u>Derived Quantities</u>**.
- Each one of the base quantities is fundamentally different from the other base quantities that it cannot be expressed in terms of the other base quantities.

  <u>Example:</u>

  Mass, length and *time* are three of the base quantities we have defined in Physics. Can you think of expressing *time* in terms of *mass* or *length* or as a combination of *mass* and *length*?

  Answer: No! It is not possible!

- Derived quantities are those physical quantities, which are derived from a combination of some of the base quantities.

  <u>Example:</u>

  Speed is a derived quantity. It can be expressed in terms of length and time.

Système international d'unités (International System of Units - SI)

- These French words refer to an internationally agreed system of measurements. This system defines 7 physical quantities as base quantities. It also defines the units of those base quantities.

Base Quantity		Base Unit	
Name	**Symbol**	**Name**	**Symbol**
Time	t	second	s
Length	l	metre	m
Mass	m	kilogram	kg
Temperature	T, θ	kelvin	K
electric current	I	ampere	A
amount of substance	n	mole	mol
luminous intensity	I_v	candela	cd

Derived Quantities and Derived Units

- All physical quantities, other than those given in the table above, are derived quantities. These quantities are derived from a combination of some of the base quantities, using a **defining equation**. The units of the derived quantities can also be derived from the defining equation.
- It is useful to remember the defining equations for some of the derived quantities we will come across in Physics. They are given in the table below along with their derived units. Note that some of the derived units have special names.

Derived Quantity	Defining Equation	Derived Unit	Special Name
Velocity	Displacement $\div$ Time Taken	ms^{-1}	
Density	Mass $\div$ Volume	kgm^{-3}	
Force	Mass $\times$ Acceleration	$kgms^{-2}$	Newton (N)
Pressure	Force $\div$ Area	$kgm^{-1}s^{-2}$	Pascal (Pa)
Work (Energy)	Force $\times$ Distance	$kgm^{2}s^{-2}$	Joules (J)
Power	Energy $\div$ Time	$kgm^{2}s^{-3}$	Watt (W)
Electrical Charge	Current $\times$ Time	As	Coulomb ©
Potential Difference	Energy $\div$ Charge	$kgm^{2}A^{-1}s^{-3}$	Volt (V)
Resistance	Potential difference $\div$ Current	$kgm^{2}A^{-2}s^{-3}$	Ohm (Ω)

Prefixes to Units

- Sometimes we come across very large or very small quantities in Physics. If these quantities are expressed in their usual units, it would be hard to read and write those quantities. To make reading and writing easier, we use some prefixes to the base units, when dealing with very large or very small quantities.

Prefix	Symbol	Multiplier
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Example:

The wavelength of an X-Ray = 0.000 000 001 m
= 1×10^{-9} m
= 1 nanometre
= 1 nm

Homogeneity of Physics Equations

All terms in a correct Physics equation should have the same unit. In other words, all Physics equations must be homogeneous in terms of units. This idea can be used to check whether a Physics equation could be correct.

Example:

Check whether the following equation could be correct.

$$s = ut + \frac{1}{2}at$$

In the equation, *s* represents displacement, *u* represents initial velocity, *a* represents acceleration and *t* represents time.