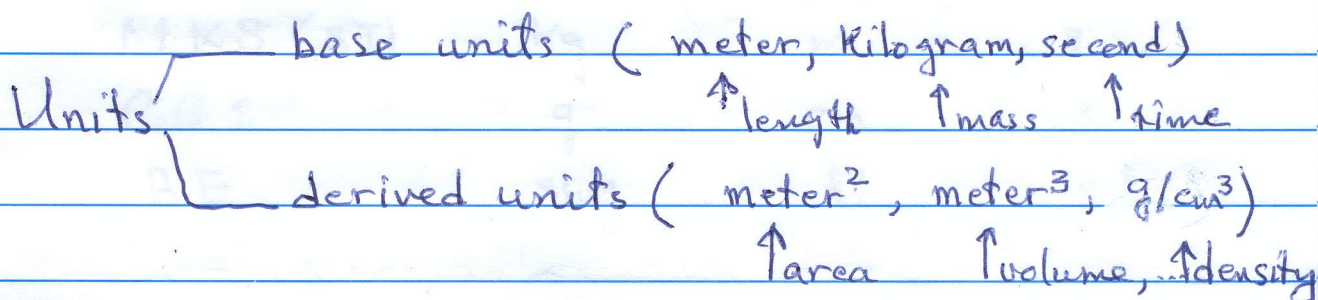


Physics and Measurements:

All physical quantities are measured in their own "units" and compared to "Standards".



Standards of Length, Mass, and Time:

Standard International System of Units (SI). In SI units $\Rightarrow$

Standard of mass: One kilogram (kg)

Standard of Length: One meter (m)

Standard of Time: One second (s)

1 kg: Platinum-Iridium alloy put under stable conditions in Paris-France.

1 m: Distance traveled by light in vacuum during a time of $\frac{1}{299792458}$ seconds.

1 s: The time required for Cs-133 atom to undergo 9192631770 vibrations

$$\text{Density } \rho = \frac{m}{V}$$

mass
volume

For Al $\Rightarrow \rho = 2.7 \text{ g/cm}^3$

Pb $\Rightarrow \rho = 11.3 \text{ g/cm}^3$

There are 3 Systems of units

<u>System</u>	<u>Mass</u>	<u>Length</u>	<u>Time</u>
MKS (SI)	kg	m	s
CGS	g	cm	s
BE	slug	ft	s

Conversion of units:

Density ρ is given in units of g/cm^3 .

$$1 \text{ g} = 1 \text{ gram} = 1 \times 10^{-3} \text{ kg}$$

$$1 \text{ cm} = 1 \times 10^{-2} \text{ m} \Rightarrow 1 \text{ cm}^3 = 1 \times 10^{-6} \text{ m}^3$$

$\Rightarrow$

$$\frac{\text{g}}{\text{cm}^3} = \frac{1 \times 10^{-3} \text{ kg}}{1 \times 10^{-6} \text{ m}^3} = 1 \times 10^3 \text{ kg/m}^3$$

$\Rightarrow$

$$\text{For Al} \Rightarrow \rho = 2.7 \frac{\text{g}}{\text{cm}^3} = 2.7 \times 10^3 \text{ kg/m}^3$$

$$1 \text{ km} = 1 \times 10^3 \text{ m}$$

$$1 \text{ kg} = 1 \times 10^3 \text{ g} \quad k = 10^3$$

$$1 \text{ kV} = 1 \times 10^3 \text{ V}$$

$$1 \text{ MV} = 1 \times 10^6 \text{ V}$$

$$1 \text{ GV} = 1 \times 10^9 \text{ V}$$

and so on.

There are also subunits

$$1 \text{ cm} = 1 \times 10^{-2} \text{ m}$$

$$1 \text{ mm} = 1 \times 10^{-3} \text{ m}$$

$$1 \text{ }\mu\text{m} = 1 \times 10^{-6} \text{ m}$$

$$1 \text{ nm} = 1 \times 10^{-9} \text{ m}$$

$$1 \text{ pm} = 1 \times 10^{-12} \text{ m}$$

$\vdots$

Mathematical Notation

$$1000 = 10^3$$

$$1000000 = 10^6$$

$$0.0015 = 1.5 \times 10^{-3}$$

$$15000 = 1.5 \times 10^4$$

Dimensional Analysis:

In any equation, both sides must have the same units

Example: Motion under constant acceleration

$$x = v_0 t + \frac{1}{2} a t^2$$

x = distance, a = acceleration, t = time

$x \Rightarrow L$ or m , $a \Rightarrow \frac{L}{T^2}$ or $\frac{m}{s^2}$, $t \Rightarrow T$ or s

Note: the constant $\frac{1}{2}$ has no units

Check the dimensions of the above equation

Left side: L or m

Right side: First term: $\frac{L}{T} \cdot T$ or $\frac{m}{s} \cdot s$
 $\Rightarrow L$ or m

Second term: $\frac{L}{T^2} \cdot T^2$ or $\frac{m}{s^2} \cdot s^2$
 $\Rightarrow L$ or m

Note: Each term on both side of the equation must have the same dimensions or units.

Suppose we have no clue on the equation except that $x \propto a^n t^k$, n, k are numbers to be determined

Prove by dimensional analysis that
 $n=1, k=2$

Left side: Has dimensions of Length L

Right side: Must have the same dimensions

$$\begin{aligned} L^1 &= \left(\frac{L}{T^2} \right)^n T^m \\ \Rightarrow L^1 &= L^n T^{m-2n} \end{aligned}$$

Comparing both sides $\Rightarrow$

$$n=1, m-2n=0 \Rightarrow m=2n=2$$

$\Rightarrow$

$$x \propto a^1 t^2$$

or

$$x \propto a t^2 \quad \text{or } x \propto a t^2$$

