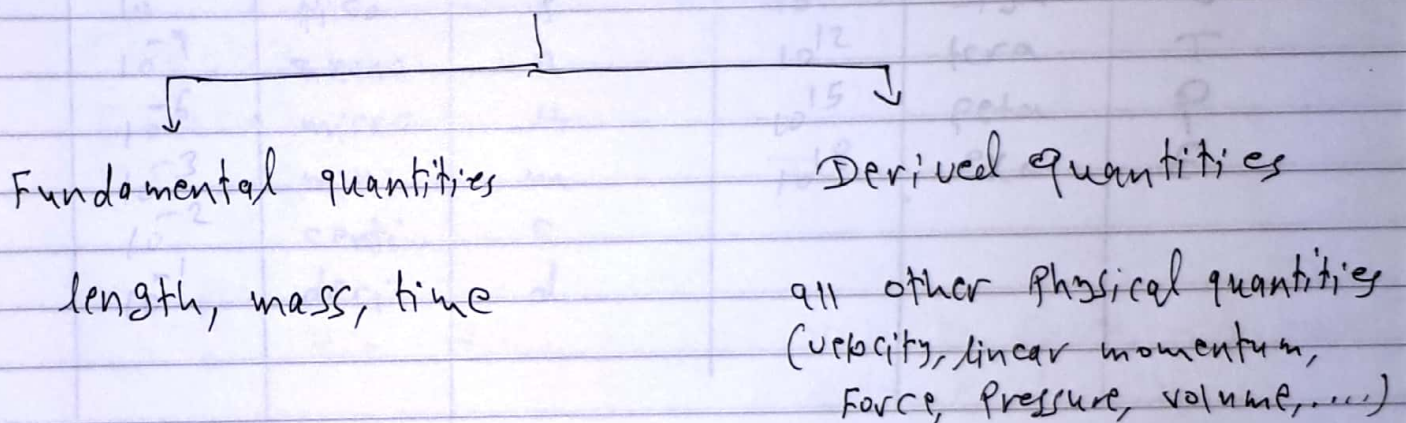


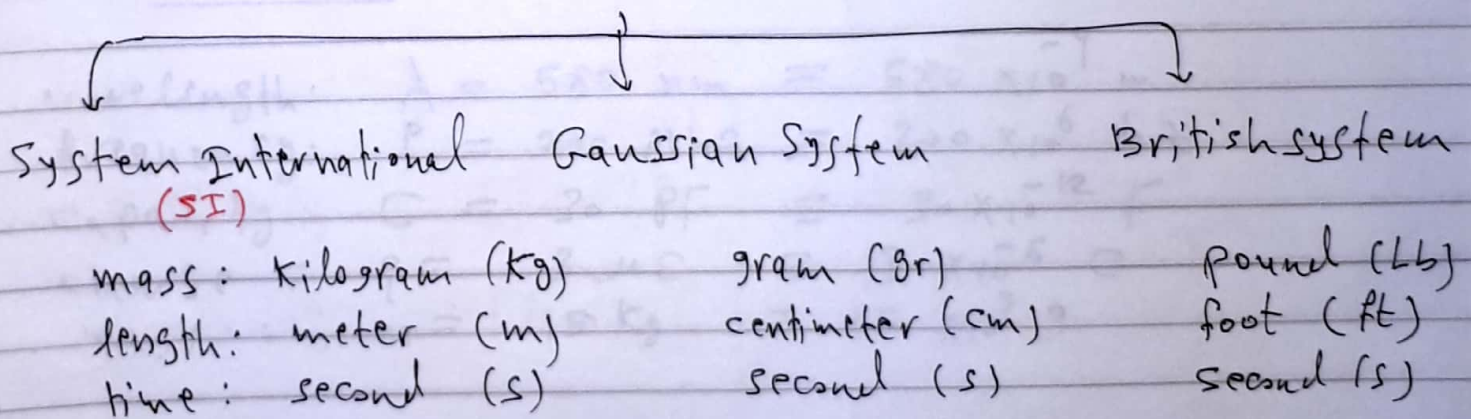
Introduction

concept of physics: physics is a fundamental science concerned with understanding the natural phenomena that occur in our universe.

Physical Quantities (in mechanics)



Units



$$1 \text{ ft} = 30.48 \text{ cm}$$

$$1 \text{ mile} = 1609 \text{ m}$$

$$1 \text{ slug} = 452 \text{ gr}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

Some prefixes for powers of ten

| Power القوة | Prefix كلمة | abbreviation اختصار | power | Prefix | abbreviation |
|----------------|----------------|------------------------|-----------|--------|--------------|
| 10^{-18} | atto | a | 10^3 | kilo | K |
| 10^{-15} | femto | f | 10^6 | mega | M |
| 10^{-12} | pico | p | 10^9 | giga | G |
| 10^{-9} | nano | n | 10^{12} | tera | T |
| 10^{-6} | micro | μ | 10^{15} | peta | P |
| 10^{-3} | milli | m | 10^{18} | exa | E |
| 10^{-2} | centi | c | | | |
| 10^{-1} | deci | d | | | |

Examples:

wavelength: $\lambda = 580 \text{ nm} \equiv 580 \times 10^{-9} \text{ m}$

frequency: $f = 200 \text{ MHz} \equiv 200 \times 10^6 \text{ Hz}$

capacity: $C = 30 \text{ pF} \equiv 30 \times 10^{-12} \text{ F}$

charge: $q = 3 \text{ } \mu\text{C} \equiv 3 \times 10^{-6} \text{ C}$

mass: $m = 15 \text{ kg} \equiv 15 \times 10^3 \text{ g}$

Dimensional Analysis

The dimension of a physical quantity x is denoted as $[x]$

| quantity | dimension |
|----------|-----------|
| [length] | L |
| [mass] | M |
| [time] | T |

Example:

What is the dimensions of velocity, force, acceleration, volume, density

$$[\text{velocity}] = \frac{[\text{length}]}{[\text{time}]} = \frac{L}{T}$$

$$[\text{acceleration}] = \frac{[\text{velocity}]}{[\text{time}]} = \frac{L/T}{T} = \frac{L}{T^2}$$

$$[\text{force}] = [\text{mass}][\text{acceleration}] = M \frac{L}{T^2}$$

$$[\text{volume}] = [\text{length}]^3 = L^3$$

$$[\text{density}] = \frac{[\text{mass}]}{[\text{volume}]} = \frac{M}{L^3}$$

| quantity | unit (SI) | dimension |
|----------|---------------------|-------------------|
| length | m | L |
| mass | kg | M |
| time | s | T |
| velocity | m/s | L/T |
| force | kg·m/s ² | ML/T ² |
| density | kg/m ³ | M/L ³ |

Consistency of units

(توافق الوحدات)

It is useful to determine whether the physical equations are correct or not.

Example:

Show whether the following equations are dimensionally correct or not?

i) $x = vt$, ii) $x = at$

where x is distance, v is velocity, t is the time
 a is acceleration

$$\begin{aligned} \text{i) } [x] &\stackrel{?}{=} [v][t] \\ L &\stackrel{?}{=} \frac{L}{T} \cdot T = L \end{aligned}$$

$$L = L$$

so that $x = vt$ is correct in dimensions

ii) ~~Example~~ $x = at$

$$[x] \stackrel{?}{=} [a][t]$$

$$L \stackrel{?}{=} \frac{L}{T^2} \cdot T = \frac{L}{T}$$

$$L \neq \frac{L}{T}$$

so that $x = at$ is not correct

Example: For what values of n and m in the equation $x = a^n t^m$ to be correct in dimensions?

$$x = a^n t^m$$

$$[x] = [a]^n [t]^m$$

$$L = \left(\frac{L}{T^2}\right)^n (T)^m = L^n T^{m-2n}$$

or $\Rightarrow L^1 T^0 = L^n T^{m-2n}$

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

$$\therefore n=1, m=2$$

Conversion of units

Example: convert $v = 100 \text{ km/hr}$ into m/s

$$v = 100 \frac{\text{km}}{\text{hr}} \cdot \frac{10^3 \text{ m}}{\text{km}} \cdot \frac{\text{hr}}{3600 \text{ s}} = 27.7 \text{ m/s}$$

Example: convert 20 ft to meters

$$20 \text{ ft} = 20 \text{ ft} \cdot \frac{30.48 \text{ cm}}{\text{ft}} \cdot \frac{\text{m}}{100 \text{ cm}} = 6.1 \text{ m}$$

Example: what is the density of a solid cube of mass 25g and length 5cm in SI units

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{25 \text{ gr}}{125 \text{ cm}^3} \cdot \frac{\text{kg}}{1000 \text{ gr}} \cdot \frac{10^6 \text{ cm}^3}{\text{m}^3} = 200 \frac{\text{kg}}{\text{m}^3}$$