Introduction

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

Physical Quantities (in mechanics)

- Fundamental quantities: length, mass, time
- Derived quantities: all other physical quantities (velocity, linear momentum, Force, Pressure, volume, ...)

Units

System International (SI)	Gaussian System	British system
mass: kilogram (kg)	gram (gr)	pound (Lb)
length: meter (m)	centimeter (cm)	foot (ft)
time: second (s)	second (s)	second (s)

1 Ft = 30.48 cm
1 mile = 1609 m
1 slug = 452 gr

1 in = 2.54 cm

Some prefixes for powers of ten

Power القوة	Prefix البادئة	abbreviation الاختصار	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: $\lambda = 580\ nm \equiv 580 \times 10^{-9}\ m$

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

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

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

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

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

i) $[x] \stackrel{?}{=} [v][t]$

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

$$L = L$$

so that $x = vt$ is correct in dimensions

ii) $x = at$

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

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

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

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

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

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

Conversion of Units

Example: convert $v = 100$ 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 25 gr and length 5 cm in SI units

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