An Introductory Lecture

Physical Quantities & Measurements

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Outlines

1. Physical quantities and Unit
2. Unit Prefix
3. Conversion of Unit

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How fast does light travel ?

How much do you weight ?

What is the radius of the Earth?

What temperature does ice melt at?

We can find the answers to all of these questions by measurement.

Speed, mass, length and temperature are all examples of physical quantities.

Measurement of physical quantities is an essential part of Physics.

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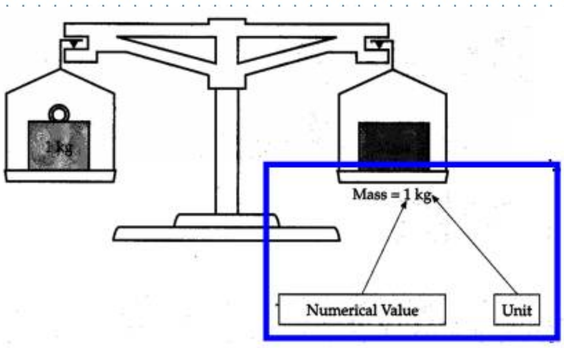
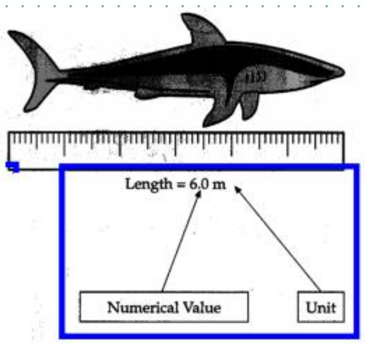
Physical Quantities

- **Quantities that are measurable with instruments in laboratory or can be derived from these measured quantities.**

- **consists of a precise numerical value & a unit.**





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- categorized into 2:

1. Basic (base) Quantities
2. Derived Quantities

Basic (Base) Quantities

- fundamental quantity that can NOT be derived in terms of other physical quantities.

Derived Quantities

- Are the physical quantities other than the base quantities.
- Are derived from base quantities according to a defining equation.

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Physical Unit

- are standards size of measurement of physical quantities.
- ex: metre (m) – unit for length
  second (s) – unit for time
  Kelvin (K) – unit for temperature

- The unit of basic quantity is called base unit.
- The unit of derived quantity is called derived unit.

SI Unit

- International System of Units
- has been agreed internationally.

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Basic (Base) Quantities & units

Base Quantity	Name of SI unit	Unit symbol
Length , *l*	metre	m
Mass, *m*	kilogram	kg
Time, *t*	second	s
Electric current, *I*	ampere	A
Temperature, *T*	kelvin	K
Amount of substance, *n*	mole	mol
Luminous intensity	candela	cd

(Table 1)

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Derived Quantities & units

Physical Quantity	Defining equation	SI unit	Special name
Velocity	v = s / t	m s^{-1}	--
Density	ρ = m / V	kg m^{-3}	--
Frequency	f = 1 / T	s^{-1}	Hz (Hertz)
Force	F = ma	kg m s^{-2}	N (Newton)
Pressure	P = F / A	kg m^{-1} s^{-2}	Pa (Pascal)
Work	W = F.s	kg m^2 s^{-2}	J (Joule)
Charge	Q = It	A s	C (Coulomb)

(Table 2)

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Examples of derived quantities

Velocity, v

$$\frac{\text{length}}{\text{time}} = \frac{l}{t} = \frac{\text{m}}{\text{s}} = \text{ms}^{-1}$$

SI Unit

Density, ρ

$$\frac{\text{mass}}{\text{volume}} = \frac{m}{V}$$

$$= \frac{\text{kg}}{\text{m}^3}$$

$$= \text{kgm}^{-3}$$

SI Unit

Force, F

$$= \text{mass} \times \text{acceleration}$$

$$= m \times a$$

$$= \text{kg} \times \text{ms}^{-2}$$

$$= \text{kg ms}^{-2} \text{ @ N}$$

SI Unit

Special Name

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Determine SI unit and special name for following physical quantities:

a) **Acceleration, a**
b) **Potential Energy, U**
c) **Power, P**

a) Acceleration, a

$$= \frac{velocity}{time} = \frac{v}{t} = \frac{ms^{-1}}{s} = ms^{-2}$$

b) Potential Energy, U

$$= mgh = kgms^{-2}m = kgm^{2}s^{-2} \text{ @ } Joule$$

c) Power, P

$$= \frac{Work}{time} = \frac{U}{t} = \frac{kgm^{2}s^{-2}}{s} = kgm^{2}s^{-3} \text{ @ } Watt \text{ @ } Js^{-1}$$

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Unit Prefixes

- It is used **for presenting larger and smaller values.**
- Table 3 shows all the unit prefixes

Prefix	Multiple	Symbol
tera	$\times 10^{12}$	T
giga	$\times 10^{9}$	G
mega	$\times 10^{6}$	M
kilo	$\times 10^{3}$	k
deci	$\times 10^{-1}$	d
centi	$\times 10^{-2}$	c
milli	$\times 10^{-3}$	m
micro	$\times 10^{-6}$	µ
nano	$\times 10^{-9}$	n
pico	$\times 10^{-12}$	p

(Table 3)

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Example of unit prefixes

Example 1

58000 m = 58 x 10^3 m

= 58 km

Example 2

0.000009 s = 9 x 10^{-6} s

= 9 µs

Example 3

5500 m = 5500 m

= 5.5 x 10^3 m

= 5.5 km

Example 4

Wavelength of an X-Ray = 0.000 000 001 m

=1 x 10^{-9} m

=1 nm

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Conversion of Unit

Depending on the instrument we use to measure a physical quantity, the unit may not expressed as an SI unit.

It is often necessary to convert the unit of a physical quantity.

Conversion unit let us express a quantity in terms of simpler unit without changing its physical value or size

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Example of Conversion of Units in SI system

1) 1 cm² ⇒ ? m²

1st method :

$$1\ \text{cm}^2 = 1\cancel{\text{cm}}^2 \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}} \times \frac{1\ \text{m}}{100\ \cancel{\text{cm}}}$$

$$= \frac{1\ \text{m}^2}{10000}$$

$$= 0.0001\ \text{m}^2$$

2nd method :

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

$$1\ \text{cm}^2 = 1 \times 10^{-4}\ \text{m}^2$$

$$= 0.0001\ \text{m}^2$$

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2) 360 km h^{-1} $\Rightarrow$? m s^{-1}

1st method :

$$= \frac{360\ \cancel{km}}{\cancel{h}} \times \frac{1000\ m}{1\ \cancel{km}} \times \frac{1\ \cancel{h}}{60\ \cancel{min}} \times \frac{1\ \cancel{min}}{60\ s}$$

$$= \frac{360 \times 1000\ m}{3600\ s}$$

$$= 100\ ms^{-1}$$

2nd method :

$$360\ \ km\,h^{-1} = \left(\frac{360\,km}{1\,h}\right)$$

$$360\ \ km\,h^{-1} = \left(\frac{360 \times 10^3\,m}{3600\,s}\right)$$

$$= 100\ \ m\,s^{-1}$$

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Example of Conversion of Units in SI system

15 km h^{-1} = 15 (1000 m) (3600 s)$^{-1}$ = 4.17 m s^{-1}

5 mm^3 = 5 (10^{-3} m)^3 = 5 x 10 $^{-9}$ m^3 = 0.000000005 m^3

7 g cm $^{-3}$ = 7 (10 $^{-3}$ kg) (10^{-2} m) $^{-3}$ = 7 x 10 $^{-3}$ x 10 ^{6} kg m^{-3} = 7000 kg m^{-3}

30 ^{o}C = 30 + 273.15 K = 303.15 K

Every answer must followed with unit of that quantity otherwise mark will be deducted in an examination.

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Follow Up Exercise 2:

1. A hall bulletin board has an area of 250 cm^2. What is this area in square meters (m^2) ?
2. The density of metal mercury is 13.6 g/cm^3. What is this density as expressed in kg/m^3
3. A sheet of paper has length 27.95 cm, width 8.5 cm and thickness of 0.10 mm. What is the volume of a sheet of paper in m^3 ?
4. Convert the following into its SI unit:

   (a) 80 km h^{-1} = _______ m s^{-1}

   (b) 450 g cm^{-3} = _______kg m^{-3}

   (c) 15 dm^3 = _______ m^3

   (d) 450 K = ________° C

   (e) 86 μF = ________ F

   (f) 100 MeV = ________ eV

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END of Lecture

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