Need for measurement: Units of measurement; systems of units; SI units, fundamental and derived units

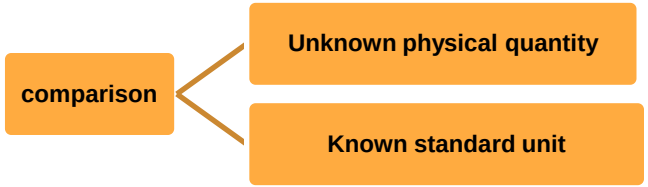
XI- SCIENCE

SUBJECT : PHYSICS
CHAPTER NUMBER: 2
CHAPTER NAME : UNITS AND MEASUREMENTS

Website: www.odmegroup.org
Email: info@odmps.org
Toll Free: 1800 120 2316
Sishu Vihar, Infocity Road, Patia, Bhubaneswar- 751024

MEASURING PROCESS

Measurement of any physical quantity involves comparison with a certain basic, arbitrarily chosen, internationally accepted reference standard called unit.



A measured value of a quantity is expressed as;

$$Q = nu \ (Q \rightarrow \text{physical quantity}, n \rightarrow \text{numeric value}, u \rightarrow \text{name of unit})$$

e.g. length of a room,

$$L = 5m \ (L \rightarrow Q, 5 \rightarrow n, m \rightarrow u)$$

As Q = constant $\Longrightarrow$ nu = constant

$$\Longrightarrow n \ \alpha \ \frac{1}{u}$$

If unit is bigger, numeric value is small.

e.g. 1m = 100 cm = 0.001 km

Units and Measurements

- **Physical Quantity**
  - A quantity which is measurable is called ‘physical quantity’.
- **Fundamental Quantity**
  - A physical quantity which is the base and can not be derived from any other quantity is called ‘fundamental quantity’.
  - Examples: Length, Mass, Time, etc.
- **Derived Quantity**
  - A physical quantity which can be derived or expressed from base or fundamental quantity / quantities is called ‘derived quantity’.
  - Examples: Speed, velocity, acceleration, force, momentum, torque, energy, pressure, density, thermal conductivity, resistance, magnetic moment, etc.

Units and Measurements

- **Unit**
  - Measurement of any physical quantity involves comparison with a certain basic, arbitrarily chosen, internationally accepted reference standard called unit.
- **Fundamental Units**
  - The units of the fundamental or base quantities are called fundamental or base units.
  - Examples: metre, kilogramme, second, etc.
- **Derived Units**
  - The units of the derived quantities which can be expressed from the base or fundamental quantities are called derived units.
  - Examples: metre/sec, kg/m^3, $kg\ m/s^2$, $kg\ m^2/s^2$, etc.

System of Units

Some internationally accepted systems of units:

Base Quantities	MKS Unit	Symbol of Unit
MKS System		
Mass	kilogram	kg
Length	meter	m
Time	second	s
CGS System		
Mass	gram	g
Length	centimeter	cm
Time	second	s

System of Units

Some internationally accepted systems of units:

Base Quantities	MKS Unit	Symbol of Unit
FPS System		
Mass	pound	lb
Length	foot	ft
Time	second	s
SI System		
Mass	kilogram	kg
Length	meter	m
Time	second	s

Systeme Internationale d’ unites (SI Units)

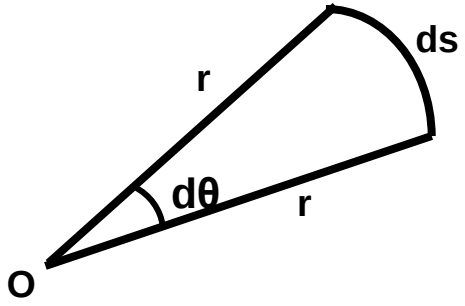
- The SI system with standard scheme of symbols, units and abbreviations was developed and recommended by General Conference on Weights and Measures in 1971 for international usage in scientific, technical, industrial and commercial work.
- This is the system of units which is at present accepted internationally.
- SI system uses decimal system and therefore conversions within the system are quite simple and convenient.

Fundamental Units in SI system

	Quantity	Symbol	SI Unit	Symbol
Seven base quantities and their Units	Length	L	metre	m
	Mass	M	kilogram	kg
	Time	T	second	s
	Electric Current	A	ampere	A
	Thermodynamic Temperature	K	kelvin	K
	Light Intensity	Cd	candela	cd
	Amount of substance	mole	mole	mol
Supplementary quantities and their Units	Plane Angle	$d\theta$	radian	rad
	Solid Angle	$d\Omega$	steradian	sr

Plane Angle

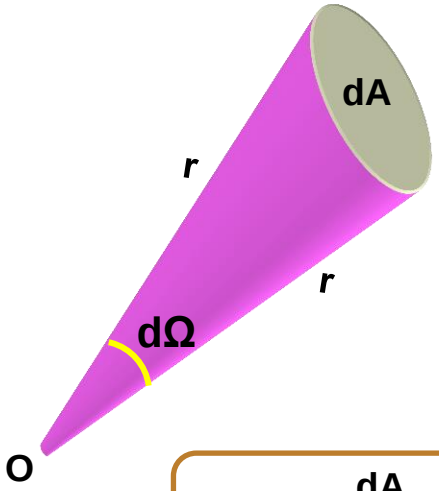
- Plane angle ‘dθ’ is the ratio of arc ‘ds’ to the radius ‘r’. Its SI unit is ‘radian’.



$$d\theta = \frac{ds}{r}$$

Solid Angle

- Solid angle ‘dΩ’ is the ratio of the intercepted area ‘dA’ of the spherical surface described at the apex ‘O’ as the centre, to the square of its radius ‘r’.
- Its SI unit is ‘steradian’.



$$d\Omega = \frac{dA}{r^2}$$

System of Units

- Except seven fundamental quantities two more dimensionless quantities are also chosen in S.I. system as supplementary quantities.
  - Angle: S.I. unit is radian
    - 1 rad $=\frac{180^0}{\pi}$
    - $1^0 = \left(\frac{\pi}{180}\right) \text{rad} = 1.745\text{x}10^{-2}\ \text{rad}$
    - $1' = \left(\frac{1}{60}\right)^0 = 2.908\text{x}10^{-4}\ \text{rad}$
    - $1'' = \left(\frac{1}{60}\right)' = \left(\frac{1}{60\text{x}60}\right)^0 = \left(\frac{\pi}{180\text{x}60\text{x}60}\right) = 4.85\text{x}10^{-6}\ \text{rad}$
  - Solid Angle: S.I. unit is steradian (sr)

System of Units

- Except the above systems, a system can also be framed by considering some quantities as fundamental quantities, but they should be independent of each other.
- Example – In a system force, length, time can be taken as fundamental quantities. But force, energy, length can't be fundamental quantities of a system.
- $\because \text{energy} = \text{force x length}$

Some Units are retained for general use (Though outside SI)

Name	Symbol	Value in SI Unit
minute	min	60 s
hour	h	60 min = 3600 s
day	d	24 h = 86400 s
year	Y	365.25 d = 3.156 x 10^7 s
Degree	0	10 = (π / 180) rad
litre	L	1 dm^3 = 10^{-3} m^3
tonne	T	10^3 kg
carat	c	200 mg

ODM PUBLIC SCHOOL
SCHOOL OF HUMAN EXCELLENCE

Some Units are retained for general use (Though outside SI)

Name	Symbol	Value in SI Unit
bar	Bar	0.1 MPa = 10^5 Pa
curie	ci	3.7 x 10^{10} s^{-1}
roentgen	r	2.58 x 10 $^{-4}$ C/kg
quintal	q	100 kg
barn	b	100 fm^2 = 10^{-28} m^2
are	a	1 dam^2 = 10^2 m^2
hectare	ha	1 hm^2 = 10^4 m^2
standard atmosphere pressure	atm	101325 Pa = 1.013 x 10^5 Pa

MCQ TYPE QUESTIONS

1. Which of the following sets of quantities can be taken as fundamental quantities of a system.
   a) force, pressure, length
   b) mass, length, density
   c) mass, speed, time
   d) acceleration, length, time
2. Which of the following quantities can’t be derived quantities in MKS system?
   a) force
   b) electrical energy
   c) electric potential
   d) pressure

MCQ TYPE QUESTIONS

3. Which of the following sets cannot enter into the list of fundamental quantities in any system of units?

(a) length, mass and velocity,

(b) length, time and velocity,

(c) mass, time and velocity,

(d) length, time and mass.

4. A physical quantity is measured and the result is expressed as nu where u is the unit used and n is the numerical value. If the result is expressed in various units then

(a) n $\propto$ size of u

(b) n $\propto u^2$

(c) n $\propto \sqrt{u}$

(d) n $\propto \frac{1}{u}$

THANKING YOU

ODM EDUCATIONAL GROUP