UNIT 1 MEASUREMENT

Warm greetings:

Dear students,

Welcome all. In this section of Science I class you get to learn about the physical quantities and units.

- Introduction
- physical quantities and units.
  - Physical quantities
  - Units
- SI system of units
- Fundamental units
- Units prefixes
- Rules and Conventions for writing SI Units and their Symbols

Introduction:

Measurement is the basis of all important scientific study. It plays an important role in our daily life also. While finding your height, buying milk for your family, timing the race completed by your friend and so on, you need to make measurements. Measurement answers questions like, how long, how heavy and how fast?

Measurement is about assigning a number to a characteristic of an object or event which can be compared with other objects or events. It is defined as the determination of the size or magnitude of a quantity. In this lesson you will learn about units of measurements and the characteristics of measuring instruments.

Physical Quantities and Units

Physical quantities:

Physical quantity is a quantity that can be measured. Physical quantities can be classified into two:

- Fundamental quantities and
- Derived quantities.

Quantities which cannot be expressed in terms of any other physical quantities are called fundamental quantities. Example: Length, mass, time, temperature etc.

Quantities which can be expressed in terms of fundamental quantities are called derived quantities. Example: Area, volume, density etc.

Physical quantities have a numerical value and a unit of measurement (say, 3 kilogram). Suppose you are buying 3 kilograms of vegetable in a shop. Here, 3 is the numerical value and kilogram is the unit. Let us study about units now.

Units:

- A unit is a standard quantity with which the unknown quantities are compared.
- It is defined as a specific magnitude of a physical quantity that has been adopted by law or convention.
- For example, feet is the unit for measuring length. That means, 10 feet is equal to 10 times the definite pre-determined length, called feet.
- Earlier, different unit systems were used by people from different countries. Some of the unit systems followed earlier are given below in Table 1.1.

Table 1.1 Unit systems of earlier times

System	Length	Mass	Time
CGS	centimetre	gram	second
FPS	foot*	pound	second
MKS	metre	kilogram	second

* foot is the singular of feet

At the end of the Second World War there was a necessity to use worldwide system of measurement. Hence, SI (International System of Units) system of units was developed and recommended by General Conference on Weights and Measures at Paris in 1960 for international usage.

SI System of Units:

SI system of units is the modernized and improved form of the previous system of units. It is accepted in almost all the countries. It is based on a certain set of fundamental units from which derived units are obtained by proper combination. There are seven fundamental units in the SI system of units. They are also known as base units and they are given in Table 1.2. The units used to measure the fundamental quantities are called fundamental units and the units which are used to measure the derived quantities are called derived units.

Table 1.2 Fundamental quantities and their units

Fundamental quantities	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Electric current	ampere	A
Luminous intensity	candela	cd
Amount of substance	mole	mol

With the help of these seven fundamental units, the units for other derived quantities are obtained and their units are given below in Table 1.3.

Table 1.3 Derived quantities and their units

S.No	Physical quantity	Expression	Unit
1	Area	length × breadth	m^2
2	Volume	area × height	m^3
3	Density	mass / volume	kgm^{-3}
4	Velocity	displacement / time	ms^{-1}
5	Momentum	mass × velocity	$kgms^{-1}$
6	Acceleration	velocity / time	ms^{-2}
7	Force	mass × acceleration	$kgms^{-2}$ or N
8	Pressure	force / area	Nm^{-2} or Pa
9	Energy (work)	force × distance	Nm or J
10	Surface tension	force / length	Nm^{-1}

Fundamental Units:

Length:

- Length is the extent of something between two points.
- The SI unit of length is metre.
- One metre is the distance travelled by light through vacuum in 1/29,97,92,458 second.
- In order to measure very large distance (distance of astronomical objects) we use the following units.
  - Astronomical unit
  - Light year

• Parsec

Astronomical unit (AU):

It is the mean distance of the centre of the Sun from the centre of the Earth.

1 AU = 1.496 X10 ^{11} m

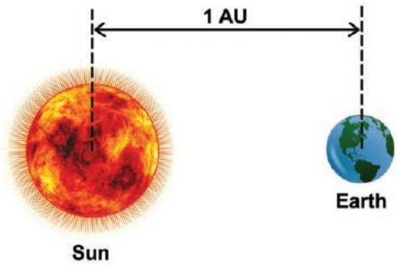

Figure 1.1 Astronomical unit

Light year:

It is the distance travelled by light in one year in vacuum and it is equal to 9.46 X10^{15} m.

Parsec:

Parsec is the unit of distance used to measure astronomical objects outside the solar system.

1 Parsec = 3.26 light year.

Table 1.4 Larger units

Larger units	In metre
Kilometre (km)	10^3 m
Astronomical unit (AU)	1.496×10^{11} m
Light year (ly)	9.46×10^{15} m
Parsec (pc)	3.08×10^{16} m

To measure small distances such as distance between two atoms in a molecule, size of the nucleus and wavelength etc. we use submultiples of ten. These quantities are measured in Angstrom unit (Table 1.5).

Table 1.5 Smaller units

Smaller units	In metre
Fermi (f) *	10^{-15} m
Angstrom (Å)*	10^{-10} m
Nanometre (nm)	10^{-9} m
Micron (micrometre μ m)	10^{-6} m
Millimetre (mm)	10^{-3} m
Centimetre (cm)	10^{-2} m

* Unit outside SI system and still accepted for use.

Mass:

- Mass is the quantity of matter contained in a body.
- The SI unit of mass is kilogram (kg).
- One kilogram is the mass of a particular international prototype cylinder made of platinum-iridium alloy, kept at the International Bureau of Weights and Measures at Sevres, France.
- The units gram (g) and milligram (mg) are the submultiples of ten (1/10) of the unit kg. Similarly quintal and metric tonne are multiples of ten (X10) of the unit kg.

  1 g = 1/1000 X 1 kg = 0.001 kg

  1 mg = 1/1000000 X 1 kg = 0.000001 kg

  1 quintal = 100 X 1 kg = 100 kg

  1 metric tonne = 1000 X1 kg = 10 quintal

Atomic mass unit:

Mass of a proton, neutron and electron can be determined using atomic mass unit (amu).

1 amu = $(1/12)^{th}$ of the mass of C^{12} atom.

Time:

- Time is a measure of duration of events and the intervals between them.
- The SI unit of time is second.
- One second is the time required for the light to propagate 29,97,92,458 metres through vacuum.
- It is also defined as 1/86, 400th part of a mean solar day.
- Larger units for measuring time are day, month, year and millennium etc.

1 millenium = 3.16 X10^9 s.

Temperature:

- Temperature is the measure of hotness or coldness of a body.
- SI unit of temperature is kelvin (K).
- One kelvin is the fraction (1/273.16) of the thermodynamic temperature of the triple point of water (The temperature at which saturated water vapour, pure water and melting ice are in equilibrium).
- Zero kelvin (0 K) is commonly known as absolute zero. The other units for measuring temperature are degree Celsius (°C) and fahrenheit (F).

Unit Prefixes:

Unit prefixes are the symbols placed before the symbol of a unit to specify the order of magnitude of the quantity. They are useful to express very large and very small quantities. k (kilo) is the unit prefix in the unit, kilometer.

A unit prefix stands for a specific positive or negative power of 10. Some unit prefixes are given in Table 1.6.

Table 1.6 Unit prefixes

Power of 10	Prefix	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

The physical quantities vary in different proportion like from 10^{-15} m being the diameter of nucleus to 10^{26} m being the distance between two stars and 9.11 X10^{-31} kg being the mass of electron to 2.2 X10^{41} kg being the mass of the milky way galaxy.

Rules and Conventions for writing SI Units and their Symbols:

1. The units named after scientists are not written with a capital initial letter.

E.g. newton, henry, ampere and watt.

2. The symbols of the units named after scientists should be written by the initial capital letter.

E.g. N for newton, H for henry, A for ampere and W for watt.

3. Small letters are used as symbols for units not derived from a proper noun.

E.g. m for metre, kg for kilogram.

4. No full stop or other punctuation marks should be used within or at the end of symbols.

E.g. 50 m and not as 50 m.

5. The symbols of the units are not expressed in plural form.

E.g. 10 kg not as 10 kgs.

6. When temperature is expressed in kelvin, the degree sign is omitted.

E.g. 283 K not as 283° K (If expressed in celsius scale, degree sign should be included e.g. 100°C not as 100 C, 108° F not as 108 F).

7. Use of solidus (/) is recommended for indicating a division of one unit symbol by another unit symbol. Not more than one solidus is used.

E.g. ms^{-1} or m/s. J/K/mol should be $JK^{-1}mol^{-1}$.

8. The number and units should be separated by a space.

E.g. 15 $kgms^{-1}$ not as 15 $kgms^{-1}$.

9. Accepted symbols alone should be used.

E.g. ampere should not be written as amp and second should not be written as sec.

10. The numerical values of physical quantities should be written in scientific form.

E.g. the density of mercury should be written as 1.36 $X10^4$ kgm^{-3} not as 13600 kgm^{-3}.

§§§§§§§§§§§§§§§§§