2. UNITS AND MEASURMENT

★ Measurement - The process in which a standard is compared with a physical quantity.

★ Physical quantity - The quantities in terms of which laws of physics can be expressed & which can be measured.

i) Fundamental physical quantities - Physical quantities which are independent. It is also called basic physical quantities. Ex - mass, length, time.

ii) Derived physical quantities - Physical quantities which depend on basic physical quantities.
Ex - Area = $l \times b$

★ Unit - The standard used to measure a physical quantity is called unit.

units are of two types

i) Basic units :- Independent units of length, mass and time, electric current etc.

ii) Derived units - Derived from the fundamental units. Ex - unit of density is derived from units of mass and volume.

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System of measurement

★ System of unit - A complete set of units used for the measurement of physical quantity.

Systems used for describing measurments of various physical quantities are

i) CGS system - cm, g, s
ii) FPS system - ft (foot), lb (pound), s
iii) MKS system - m, kg, s, A (ampere)
iv) SI system (1960, general conference of weight and measurement.

SI - International system of units.

Basic physical quantity & their SI units

1.	Length (l)	metre (m)
2.	Mass (m)	kilogram (kg)
3.	Time (t)	second (s)
4.	Electric current (I)	ampere (A)
5.	Temperature (T)	kelvin (K)
6.	Amount of substance (n)	mole (mol)
7.	Luminous intensity (Iv)	candela (cd)

Two supplymentry physical quantity

1.	Plane angle	radian	rad
2.	Solid angle	steradian	Sr

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★ Characteristics of S.I unit system

- internationally accepted
- Coherent
- Rationalized
- Decimal system
- Suitable size

★ Prefixes used in measurement

femto (f)	10^{-15}	deca (da)	10^{1}
pico (p)	10^{-12}	hecto (h)	10^{2}
nano (n)	10^{-9}	kilo (k)	10^{3}
micro (μ)	10^{-6}	Mega (M)	10^{6}
milli (m)	10^{-3}	giga (G)	10^{9}
centi (c)	10^{-2}		
deci (d)	10^{-1}		

Ex - 1 mm = ? km

$$\frac{1\,mm}{1\,km} = \frac{10^{-3}\,m}{10^{3}\,m} = 10^{-3-3} = 10^{-6}\,km$$

Some practical units

★ Small distances

1. fermi
(also known as femtometer) used to measure nuclear size.

$$\boxed{1 \text{ fermi} = 10^{-15} m}$$

2. Angstrom (A)
used to measure wavelength of light.

$$\boxed{1 A = 10^{-10} m}$$

3. Micron
also known as micrometre.

$$\boxed{1 \mu m = 10^{-6} m}$$

★ Large distance

1. Light year
Distance travelled by light in vaccum in 1 year.

$$\boxed{1 L.Y = 9.467 \times 10^{15} m}$$

2. Astronomical unit (A.U)
Average distance between the earth & the sun

$$\boxed{1 A.U = 1.496 \times 10^{11} m}$$

3. Parsec (Parallactic second)
distance at which an arc of length one A.U substends angle 1s.

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$\because \quad \theta = l/r$

$r = l/\theta$

$$1 \text{ parsec} = \frac{1 A \cdot U}{1 S} = \frac{1.496 \times 10^{11}}{1/3600 \times \pi/180}$$

$$\boxed{\begin{array}{l} 1 \text{ parsec} = 3.08 \times 10^{16} m \\ 1 \text{ parsec} = 3.26 \text{ light year} \end{array}}$$

★ **Area**

1. 1 Acre = $4047 \, m^2$

2. 1 Hectare = $10^4 \, m^2$

★ **Mass**

1. 1 Quintal = 100 kg

2. 1 tonne = 1000 kg

3. 1 pound = 0.4536

4. C. S. L (chandra shekhar limit) = 4 x mass of sun.

★ **Some approximate masses**

Our galaxy	2×10^{41} kg
Sun	2×10^{30} kg
Moon	7×10^{22} kg
Asteroid Eros	5×10^{15} kg

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Dimension

The powers raised to basic physical quantity when a physical quantity is expressed in terms of basic physical quantity are called dimensions.

Dimensional equation

The equation which expresses a physical quantity in terms of the fundamental units of mass, length and time, is called dimensional equation.

Dimensional symbol

Mass	M
Length	L
Time	T
Temperature	K or θ
Electric current	A
Luminous intensity	J
Amount of substance	N

Some important dimensions

Area = length x breadth = $M^0L^2T^0$

Volume = length x breadth x height = $M^0L^3T^0$

Speed = Distance/Time = $M^0L^1T^{-1}$

Velocity = Displacement/Time = $M^0L^1T^{-1}$

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Acceleration = $\frac{\text{change in velocity}}{\text{Time}}$ = $M^0L^1T^{-2}$

Force = Mass x acceleration = $M^1L^1T^{-2}$

Density = Mass / volume = $M^1L^{-3}T^0$

Momentum = Mass x velocity = $M^1L^1T^{-1}$

Work = Force x displacement = $M^1L^2T^{-2}$

Energy = $\frac{1}{2}$ x mass x(velocity)^2 = $M^1L^2T^{-2}$

Power = work done/Time = $M^1L^2T^{-3}$

Pressure = Force /Area = $M^1L^{-1}T^{-2}$

Frequency = velocity / wavelength = $M^0L^0T^{-1}$

__Always remember__

Force MLT^{-2}
Energy ML^2T^{-2}
Speed or velocity $M^0L^1T^{-1}$
Acceleration $M^0L^1T^{-2}$
acceleration due to gravity (g) $M^0L^1T^{-2}$
Gravitational constant (G) $M^{-1}L^3T^{-2}$

General form of dimensional formula = $M^aL^bT^c$
where a, b & c are dimension (any integer)

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Four types of physical quantities on the basic of dimensions :

1. Dimensional P.Qs - area, volume, pressure etc.

2. Dimensionless P.Qs - Straine, relative density.

3. Dimensional constant - G, plank's constant

4. Dimensionless constant - π, e, numerical value.

★ **Principle of homogeneity**

If the dimensions of left hand side of an equation are equal in the dimensions of right hand side of the equation, then the equation is dimensionally correct.

★ **Uses of dimensions**

1. To find unit of a physical quantity.

2. To check correctness of a physical relation.

3. To obtain a relation between different P.Qs

4. To change a physical quantity from one system of units to another system of units.

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$$n_1 u_1 = n_2 u_2$$

where n is numerical value and u is unit in different system.

$$\boxed{n_2 = n_1 \left(\frac{M_1}{M_2}\right)^a \left(\frac{L_1}{L_2}\right)^b \left(\frac{T_1}{T_2}\right)^c}$$

★ Limitations of dimension

1. Numerical values have no dimension.

2. It does not ~~any~~ give any information about the proportionality constant k.

3. It fails to stablish a relation which contain trigonometric exponential, lagorithmic function etc.

4. It fails to find the relation if a P.Q depends upon more than 3 factors.

5. It fails to find the relation if it contains gravitational constant, plank's constant, stefan's constant etc.

6. It fails to establish the relation if it is in the form of addition and subtraction.

Significant figures

Those digits in a measurement which are certain and plus one more digit which is uncertain are called significant figures.

Ex - 72.2 , S.F = 3

★ Higher is the no of significant figures in a measurement, there is more accuracy.

Rules of significant figures

1. All non-zero digits are significant.
   Ex - 4362 S.F = 4

2. All zeros between non zero digits are significant.
   Ex - 1005 S.F = 4

3. All zeros to the right of the last non zero digit are not significant.
   Ex - 6250 S.F = 3

4. In a digit less than one, all zeroes to the right of a decimal point and to the left of a non zero digit are not significant.
   Ex - 0.00325 S.F = 3

5. All zeroes to the right of a decimal point are significant.
   Ex - 161.00 S.F = 5

6. All zeros to the right of a non zero digit in the decimal part are significant.

Ex - 1.4750 S.F = 5

7. The number of significant figures does not depend on system of units.

Ex - 16.4 cm or 16.4 m = 1640 cm

SF = 3

Rules of Rounding off significant figures

1. If the digit to be dropped is less than 5, then preceding digit is left unchanged. Ex - 1.54 → 1.5

2. If the digit to be dropped is greater than 5, then the preceding digit is raised by one.

Ex - 2.49 → 2.5

3. If the digit to be dropped is 5 followed by digit other than zero, then the preceding digit is raised by one. Ex - 3.55 → 3.6

4. If the digit to be dropped is 5 or 5 followed by zeros, then the preceding digit is raised one, if it is odd and left unchanged if it is even. Ex - 3.750 → 3.8

3.650 → 3.6