CHAPTER 1
MEASUREMENTS

Base Quantities :

3 in number i-e length, mass, time

Fundamental Quantities :

7 in number

Every base Quantity is a fundamental quantity but every fundamental quantity is a base quantity

System Of Units

1. MKS (metre, kilogram, second)
2. CGS (centimetre, gram, second)
3. FPS (foot, pound, second)

* In FPS System, Force is a fundamental physical quantity

* The unit of mass in FPS System is sluge. In FPS System mass is a derived quantity

1 sluge = 14.6 kg

PHYSICAL QUANTITY	BASE UNIT	DIMENTION
1. Newton (N)	$kg\,ms^{-2}$	$[MLT^{-2}]$
2. Joule (J)	Nm / kgm^2s^{-2}	$[ML^2T^{-2}]$
3. Watt (W)	Js^{-1} / kgm^2s^{-3}	$[ML^2T^{-3}]$
4. Pascal (Pa)	$Nm^{-2} / kgm^{-1}s^{-2}$	$[ML^{-1}T^{-2}]$
5. Columb (C)	As	
6. Angular Velocity (ω)	rad/sec	$[T^{-1}]$
7. Angular Momentum (L)	$kg\,m^2s^{-1}$	$[ML^2T^{-1}]$
8. Moment of Inertia (I)	kgm^2	$[ML^2]$
9. Torque	$Nm = kgm^2s^{-2}$	$[ML^2T^{-2}]$
10. Young's Modulus (Y)	Nm^{-2}	$[ML^{-1}T^{-2}]$
11. Surface Tension (S)	Nm^{-1}	$[MT^{-2}]$
12. Co-efficient of Viscosity (η)	$kgm^{-1}s^{-1}$ (Nsm^{-2})	$[ML^{-1}T^{-1}]$
13. Volt	JC^{-1}	$[ML^2T^{-3}A^{-1}]$
14. Magnetic Flux (Wb)		$[ML^2T^{-2}A^{-1}]$
15. Mutual Inductance (M)	Henry (H) $\rightarrow VsA^{-1}$	$[ML^2T^{-2}A^{-2}]$
16. Self Inductance (L)	$H \rightarrow VsA^{-1}$	$[ML^2T^{-2}A^{-2}]$

QUANTITIES HAVING SAME DIMENSIONS

1. Work, Energy, Torque → $[ML^2T^{-2}]$
2. Surface Tension, Surface Energy → $[ML^0T^{-2}]$
3. Angular Velocity, Frequency → $[M^0L^0T^{-1}]$
4. Pressure, Young's Modulus → $[ML^{-1}T^{-2}]$
5. Electromotive Force, Potential Difference
6. Plank's constant, Angular Momentum
7. Momentum, Impulse
8. Electrical Resistance, Impedance
9. Density, Molar concentration
10. Distance, Displacement, Amplitude
11. Decay Constant, Frequency
12. Self Inductance, Mutual Inductance, Permeability of free spa

Newton , N $\Rightarrow$ $kg\,m\,s^{-2}$

Joule , J $\rightarrow$ $Nm = kgm^2s^{-2}$

Watt, W $\rightarrow$ $Js^{-1} = kgm^2s^{-3}$

Pascal , Pa $\rightarrow$ $Nm^{-2} = kgm^{-1}s^{-2}$

Coulomb, C $\rightarrow$ As

RADIAN

$$\theta = \frac{s}{r}$$

For one Revolution:

$\theta = 2\pi$ radian

$\theta = 2 \times 3.14$ rad

$\theta = 6.28$ rad

For two Revolution:

$\theta = 2\,(2\pi \text{ rad})$

A General Formula:

$$\theta = \left(\frac{2\pi}{T}\right) t$$

DEGREE

For one revolution, $\theta = 360^\circ$

2π radian $= 360^\circ$

π rad $= 180^\circ$

1 rad $= 57.3^\circ$

$1^\circ = 0.017$ rad

STERADIAN

For complete sphere

$\theta = 4\pi$ Sr

$\theta = 4 \times 3.14$ Sr

$\theta = 12.56$ Sr

For steradian:

$\theta = \frac{A}{r^2}$

Hence total number of steradians for a sphere are 12.56 Sr

For Semisphere: $\theta = 2\pi$ Sr

For Quarter sphere: $\theta = \pi$ Sr

ERROR

Error

- Magnitude of error
- Relative Error

Magnitude of Error = Actual Difference

Relative Error = $\frac{\text{Error}}{\text{Measured Value}}$

Precision: A measurement is said to be precise if it has less magnitude of error

Accurate: A measurement is said to be accurate if it has less relative error

SIGNIFICANT FIGURES

1. All non-zero digits are significant. There may be decimal point in between and location of decimal doesnot matter
2. All zeros between two non zero digits are significant. Location of decimal doesnot matter.
3. If number is without decimal part, then the terminal or trailing zeros are not significant.
4. Trailing zeros in the decimal part are significant.
5. Any zero to the right of a non zero digit is significant. All zeros between decimal point and first non zero digit are not significant.

   0.00876 has 3 significant figures

* ADDITION AND SUBTRACTION

In adding or subtracting numbers, the number of decimal places retained in the answer should equal the smallest number of decimal places in any of the quantities being added or subtracted. In this case, the number of significant figures is not important.

9.725 km
- 4.04 km
5.685 → Rounds off to 5.68 km

* MULTIPLICATION AND DIVISION

Final result is limited to least number of significant figures.

ROUNDING OFF NUMBERS

* Rule #1

If the digit to be dropped is greater than 5, then add 1 to the last digit to be retained and drop all digits farther to the right

* Rule #2

If the digit to be dropped is less than 5, then simply drop it without adding any number to the last digit

* Rule #3

If the digit to be dropped is exactly 5 then:

1) If the digit to be retained is even, then just drop the 5.

6.65 → 6.6

2) If the digit to be retained is odd, then add 1 to it.

6.35 → 6.4

3) If the digit to be retained is zero, then just drop the 5

3.05 → 3.0

PRECISION AND ACCURACY

→ The term precision stands for the magnitude of error in a measurement

→ Accuracy stands for relative error i-e error divided by measured quantity

→ Smaller the least count of instrument, more precise is the measurement

→ Smaller the percentage error, more accurate is the measurement.

→ Absolute uncertainty is equal to least count of measuring instrument.

UNCERTAINTY

1. ABSOLUTE UNCERTAINTY

Maximum possible uncertainty which is equal to least count of measuring instrument.

It shows precision

2. FRACTIONAL OR RELATIVE UNCERTAINTY

$$\text{Relative Uncertainty} = \frac{\text{Absolute Uncertainty}}{\text{Measured Value}}$$

It shows accuracy

3. PERCENTAGE UNCERTAINTY

$$\%\ \text{Uncertainty} = \text{Fractional Uncertainty} \times 100\%$$

INDICATING UNCERTAINTY

1. ADDITION / SUBTRACTION

Absolute Uncertainties are added

2. MULTIPLICATION / ~~SUBTRACTION~~ DIVISION

% Uncertainties are added

3. IN CASE OF POWER

Power x % Uncertainty

MEAN VALUE

MDM : Mean → Deviation → Mean

e.g : 1.50 cm , 1.51 cm , 1.52 cm

i) $\text{Mean} = \frac{1.50 + 1.51 + 1.52}{3} = 1.51 \text{ cm}$

ii) Deviation = 0.01 cm , 0.00 cm , 0.01 cm

(This is magnitude of deviation which can never be negative)

iii) $\text{Mean} = \frac{0.01 + 0.00 + 0.01}{3}$

$= \frac{0.02}{3} = 6.67 \times 10^{-3} \text{ cm}$

PERIODIC TIMINGS

Uncertainty in Periodic Timings = $\frac{\text{Uncertainty}}{\text{No. of vibrations}}$

DIMENTIONS

1. $\sqrt{LC} \rightarrow [T]$ $\quad \therefore \omega = \frac{1}{\sqrt{LC}}$

2. ~~Energy Density.~~

2. $\frac{1}{2}\varepsilon_0 E^2$ = Energy Density $\rightarrow [ML^{-1}T^{-2}]$

Energy Density = $\frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} = [ML^{-1}T^{-2}]$

3. $\frac{L}{R} = [T]$

4. Gravitational Constant, $G = [M^{-1}L^3T^{-2}]$

$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

5. $RC = [T]$

6. Relative Permittivity $\rightarrow$ Dimentionless

$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$

7. $\varepsilon_0 \mu_0 \rightarrow [L^{-2}T^2]$

8. Earth's gravitational field strength 'g' ($9.8 ms^{-2}$)
   Dimention same as acceleration $[LT^{-2}]$

* The ratio of dimention of acceleration to velocity is same as 'angular Frequency' i-e $[T^{-1}]$

* Only Quantities with same dimentions can be added or subtracted

LIMITATIONS OF PRINCIPLE OF HOMOGENEITY

1. Cannot differentiate b-w vector and scalar
2. Dimentional Analysis cannot calculate constant of proportionality
3. It fails to derive formula having trigonometric functions.

* 1 Fermi $= 10^{-15}$ m
* Erg : Unit of energy

1 Erg $= 10^{-7}$ J

Atto	$\rightarrow 10^{-18}$
Femto	$\rightarrow 10^{-15}$
Pico	$\rightarrow 10^{-12}$
Nano	$\rightarrow 10^{-9}$
Micro	$\rightarrow 10^{-6}$
Milli	$\rightarrow 10^{-3}$
Centi	$\rightarrow 10^{-2}$
Deci	$\rightarrow 10^{-1}$
Deca	$\rightarrow 10^{1}$
Kilo	$\rightarrow 10^{3}$
Mega	$\rightarrow 10^{6}$
Gega	$\rightarrow 10^{9}$
Tera	$\rightarrow 10^{12}$
Peta	$\rightarrow 10^{15}$
Exa	$\rightarrow 10^{18}$