ICSE : NOTES : CHAPTER-1 : MEASUREMENT AND EXPERIMENTATION : PHYSICS

1. MEASUREMENT: Measure of a physical quantity

= Numerical value of the quantity x size of the unit=nu

i.e., $n_1u_1 = n_2u_2$ if $u_1 > u_2 \Rightarrow n_1 < n_2$

2. SYSTEM OF UNITS:

i. ***CGS System:*** cm, g, s: Metric system: F-dynes, E-ergs, P-ergs/s.
Disadvantage: inconveniently small.

ii. ***FPS System:*** foot, pound, second: F-poundal, E-foot poundal, P- foot poundal/s
Disadvantage: inconvenient multiples (for conversion).

iii. ***MKS System:*** m, kg, s: metric system: F- Newton, E-Joule, Power- Joule/second.
Disadvantage: confined to mechanics only (L, M, T)

iv. ***SI System***: This system contains seven fundamental units and two supplementary fundamental units. Internationally accepted.

3. SI SYSTEM: Rationalised, Modified MKS System. http://www.physicsinduction.com

i. **Coherent:** derived units are obtained without introducing numerical factors.

ii. **Rational:** one unit assigned for a particular physical quantity. For example, joule is used for all kinds of energy.

iii. **Absolute:** No gravitational units.

iv. **Metric:** powers of 10.

a) Fundamental Quantities:

S.No.	Fundamental Quantities	Fundamental Units	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	S
4.	Temperature	kelvin	K
5.	Electric Current	ampere	A
6	Luminous intensity	candela	cd
7	Amount of substance	mole	mol

Supplementary Fundamental Units:

S.No.	Supplementary Quantities	Fundamental Units	Symbol
1	Plane angle	radian	rad
2	Solid angle	steradian	Sr

Properties:

i. **Invariability:** can't be varied, fixed scale, can't be changed.

ii. **Availability:** should be easily made accessible. http://www.physicsinduction.com

4. Derived Quantities: Quantities that can be expressed in terms of some other quantities are called derived quantities. For example: Area, Velocity, acceleration, force etc.

5. S.I. Prefixes:

Power of 10	Prefix	Symbol	Power of 10	Prefix	Symbol
10^{18}	exa	*E*	10^{-2}	centi	*c*
10^{15}	peta	*P*	10^{-3}	milli	*m*
10^{12}	tera	*T*	10^{-6}	micro	μ
10^{9}	giga	*G*	10^{-9}	nano	*n*

10^6	mega	*M*	10^{-12}	pico	*p*
10^3	kilo	*k*	10^{-15}	femto	*f*
10^2	hecto	*h*	10^{-18}	atto	*a*
10^1	deca	*da*	10^{-21}	zetta	*z*
10^{-1}	deci	*d*	10^{-24}	yotta	*y*

6. UNITS OF LENGTH:

a) SI unit of length: metre, m http://www.physicsinduction.com

1 metre: It is the distance travelled by light in $\frac{1}{299,792,458}$ of a second in air/vacuum.

b) Units to measure large distances:

i. Parallactic second(parsec): 1 parsec = 3.08 x 10^{16}m = 3.26 ly

ii. Light year: 1 ly = 9.5 x 10^{15} m

iii. Astronomical Unit: 1 A.U. = 1.496 x 10^{11} m (planets)

c) Units to measure smaller distances:

i. Centimeter (cm): $\frac{1}{100}$th part of a metre. 1 cm = $\frac{1}{100}$ m = 10^{-2} m

ii. Millimetre (mm) : $\frac{1}{1000}$th part of a metre. 1 mm = $\frac{1}{1000}$ m = 10^{-3} m

iii. Micrometre or micron: 1 millionth part of a metre = $\frac{1}{1000000}$ th part of a metre.

1 µm = $\frac{1}{1000000}$ m = 10^{-6} m http://www.physicsinduction.com

iv. Nanometre (nm) : 1 billionth part of a metre = $\frac{1}{1000000000}$ th part of a metre.

1 nm = $\frac{1}{1000000000}$ m = 10^{-9} m

d) Units to measure much smaller distances:

i. Microns: 10^{-6} m. (wavelength)

ii. Angstrom: 1 A° = 10^{-10}m. (Atomic Physics)

iii. X-ray Unit: obsolete unit: 10^{-13}m

iv. Fermi: 10^{-15}m. (Nuclear Physics)

1 A° = 10^{-1} nm, 1 micron = 10000 A°, 1 nm = 10 A°

7. DIRECT METHODS FOR MEASURING LENGTH:

i. Meter scale: 10^{-3}m – 10^{2}m

ii. Vernier Caliipers: 10^{-4}m.

iii. Screw Gauge and Spherometer: 10^{-5}m.

8. MEASUREMENT OF MASS:

a) SI unit of mass: kilogram, kg http://www.physicsinduction.com

1 kg: mass of a cylindrical piece of platinum-iridium alloy kept at the International Bureau of Weights and Measures in Paris

b) Units to measure smaller mass (sub-units of kilogram):

i. 1 gram (g): $\frac{1}{1000}$th part of a gram. 1 g = $\frac{1}{1000}$ kg = 10^{-3} kg

ii. 1 Milligram (mg) : 1 millionth part of a kilogram = $\frac{1}{1000000}$ th part of a kilogram.

1 mg = $\frac{1}{1000000}$ kg = 10^{-6} kg

c) Units to measure larger mass:

i. Chandra Shekhar limit (CSL) = 1.4 times the mass of the Sun

ii. I metric tonne=1000kg

iii. 1quintal= 100 kg

iv. Solar mass = 2 x 10^{30} kg

d) Non-metric unit of mass:

i. 1 unified atomic mass, 1u = 1.66 x 10^{-27} kg
ii. 1 slug = 14.57 kg
iii. 1 lb = 1 pound = 0.4536 kg http://www.physicsinduction.com

9. MEASUREMENT OF MASS:

i. For measurement of gravitational mass: Common balance based on principle of moment of force
ii. For measurement of inertial mass: inertial balance- T α √m => $\frac{T_1}{T_2} \alpha \left(\frac{m_1}{m_2}\right)^{\frac{1}{2}}$
iii. For measurement of weight: spring balance- based on Hook's law, W=mg
iv. For measurement of large masses: gravitational method(ch-8)
v. For measurement of small masses (atomic/sub-atomic particles): mass spectrograph- radius of the trajectory is proportional to the mass of charged particle moving in uniform electric and magnetic field. http://www.physicsinduction.com

10. MEASUREMENT OF TIME:

a) SI unit of time: second, s

1 s: A second is the time interval of 9, 192, 631, 770 vibrations of radiation corresponding to the transition between the two hyperfine levels of the ground state of Cs – 133 atom.

b) Some Practical units for measurement of Time:

Century, Year, Lunar Month(27.3days), Solar Day (rot. Of the Earth w.r.t. the Sun), Sedrial Day (w.r.t. Star), Solar year=365.25 avg solar days= 366.25 sedrial days, Tropical year(total solar eclipse), leap year(29 days in feb), shake(10^{-8} s) http://www.physicsinduction.com

c) Units of time:

i. 1 minute = 60 s
ii. 1 hour = 60 min = 3600 s
iii. 1 day = 24 h = 24 x 60 min = 1440 min = 1440 x 60 s = 86400 s
iv. 1 year = 365 days = 365 x 86400 s = 3.1536 x 10^7 s
v. 1 decade = 10 years
vi. 1 century = 100 years
vii. 1 millennium = 1000 years

11. MEASUREMENT OF TIME:

Cs atomic clock: Uncertainty- 10^{-13}s
Quartz crystal clock: Uncertainty- 10^{-9}s

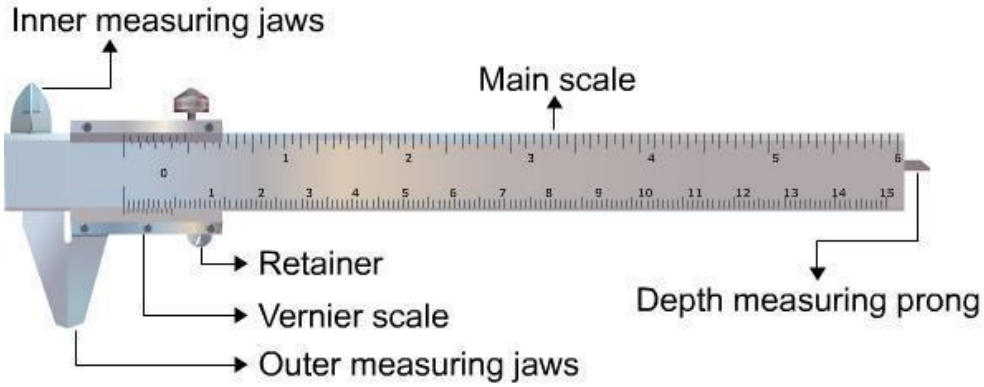
12. VERNIER CALLIPERS: Vernier Calipers was designed by Pierre Vernier. It is used to measure small lengths of solid objects and to measure the depths and internal and external diameters of an object. It consists of a main scale and a vernier scale.

Vernier Constant (least count):

1 M.S.D = 1 mm
10 V.S.D = 9 M.S.D. http://www.physicsinduction.com
1 V.S.D. = 9/10 M.S.D. = 0.9 M.S.D.= 0.9 mm
Vernier Constant, V.C. = 1 M.S.D. – 1V.S.D. = 1mm – 0.9mm = 0.1 mm = 0.01 cm
When a body is between the jaws of the Vernier Caliper;
If the zero of the vernier scale lies ahead of the Nth division of the main scale, then the main scale reading (MSR) is N
If nth division of Vernier scale coincides with any division of the main scale, then the Vernier scale reading (VSR) is;

VSR = n x L.C, (L.C is least count of vernier calliper)

Total reading,
TR=MSR+VSR=N+(n × L.C).....(2)



Zero error: zero of the main scale does not coincide with the zero of the vernier scale.
Types of zero error: (i) Positive zero error (ii) Negative zero error

i. *Positive zero error:* zero of the vernier scale is shifted to the right of the zero of the main scale. http://www.physicsinduction.com

Z. E. = n x L.C.

ii. *Negative zero error:* zero of the vernier scale is shifted to the left of the zero of the main scale.

Z. E. = -(10 – n) x L.C.

Corrected reading = Observed reading $\mp$zero error

Note: If the zero error is positive, we need to subtract the error value. If the zero error is negative, we need to add the error value. http://www.physicsinduction.com

13. SCREW GUAGE:

Pitch = $\frac{Distance\ moved\ on\ linear\ scale}{Number\ of\ rotations\ given\ to\ the\ screw}$ = 1 mm

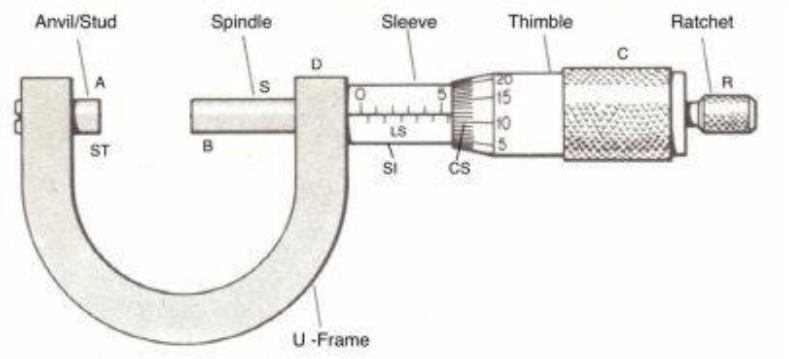
Number of divisions on the circular scale = 100

Least Count = $\frac{1\ mm}{100}$ = 0.01 mm = 0.001 cm

TR = LSR + (n X L.C.)

Where, LSR: Linear Scale Reading http://www.physicsinduction.com

n: Number of circular division coinciding



Zero error: zero of the head scale coincides with the pitch scale axis.
Types of zero error: (i) Positive zero error (ii) Negative zero error

i. *Positive zero error:* zero mark on the circular scale is below the pitch scale.

Z. E. = n x L.C.

ii. *Negative zero error:* zero mark on the circular scale is above the baseline of the main scale.

Z. E. = -(100 – n) x L.C.

Corrected reading = Observed reading ∓zero error

Note: If the zero error is positive, we need to subtract the error value. If the zero error is negative, we need to add the error value.

14. SIMPLE PENDULUM: http://www.physicsinduction.com

One complete to-and-fro motion of a body is taken as a vibration or an oscillation.

LENGTH: It is the distance of the point of oscillation from the point of suspension. It is denoted by l.

TIME PERIOD: The time taken to complete one oscillation is called time period.

Time Period = Time taken/Number of oscillations.

S.I. Unit of time period is second(s). http://www.physicsinduction.com

FREQUENCY: The no. of oscillations per second is called frequency.

Frequency = Number of oscillations/Time taken

Frequency = $\frac{1}{Period}$

S.I. Unit of Frequency is Hertz (Hz).1 Hz=$1s^{-1}$

AMPLITUDE: The maximum displacement of a vibrating body from its mean position on either side is called the amplitude of vibrations. It is measured in metre (m).

Experimentally,

$T \alpha \sqrt{l}$ ⇨ $T^2 \alpha l$

Expression for the time period of Simple Pendulum: $T = 2\pi \sqrt{l/g}$

l : length of the pendulum, g: acceleration due to gravity http://www.physicsinduction.com

Note:

i. T depends on l and g.

ii. T does not depend on the mass of the body suspended and the extent of swing on either side. http://www.physicsinduction.com