SHORT NOTES: CLASS 11

CHAPTER 1: UNITS AND MEASUREMENT

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.

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

ii. **Rational:** one unit-assigned for a particular physical quantity. E.g., joule 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

For definitions of base units: Refer NCERT

Properties:

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

ii. **Availability:** should be easily made accessible.

4. Derived Quantities: *Refer NCERT*

5. S.I. Prefixes:

Power of 10	Prefix	Symbol	Power of 10	Prefix	Symbol
10^{18}	exa	*E*	10^{-18}	atto	*a*
10^{15}	peta	*P*	10^{-15}	femto	*f*
10^{12}	tera	*T*	10^{-12}	pico	*p*
10^{9}	giga	*G*	10^{-9}	nano	*n*
10^{6}	mega	*M*	10^{-6}	micro	μ
10^{3}	kilo	*k*	10^{-3}	milli	*m*

10^2	hecto	*h*	10^{-2}	centi	*c*
10^1	deca	*da*	10^{-1}	deci	*d*

6. MEASUREMENT OF LENGTH:

a) Some Practical units for the measurement of Length:

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)
iv. Microns: 10^{-6} m. (wavelength)
v. Angstrom: 1 A^o = 10^{-10}m. (Atomic Physics)
vi. X-ray Unit: obsolete unit: 10^{-13}m
vii. Fermi: 10^{-15}m. (Nuclear Physics)

b) 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.

7. MEASUREMENT OF MASS:

a) Some Practical units for the measurement of Mass:

i. Chandra Shekhar limit (CSL) = 1.4 times the mass of the Sun
ii. I metric tonne=1000kg
iii. 1quintal= 100 kg
iv. 1unified atomic mass, 1u = 1.66 x 10^{-27} kg

b) 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.

8. MEASUREMENT OF TIME:

a) 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)

b) Measurement of Time:

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

9. ACCURACY, PRECISION OF INSTRUMENTS AND ERRORS IN MEASUREMENT:

i. Accuracy: x_i ⟶ x (true value) ii. ii. Precision: degree of exactness
iii. Errors: uncertainty

10. TYPES OF ERRORS:

i. Systematic Errors: tend to be in one direction (either +ve or -ve), causes known, can be minimized. Sources: Instrumental errors, imperfection in experimental technique or procedure, personal errors.

ii. Random Errors: chance errors, occur irregularly, fluctuations, can be minimized by repeated observations.

iii. Least count Error: least-smallest, count-value, associated with the resolution of the instrument. Can be minimized by using instruments of higher precision or by repeating observations and taking mean.

11. ABSOLUTE ERROR, RELATIVE ERROR AND PERCENTAGE ERROR:

True value: Arithmetic mean of n number of observations: $a_1, a_2, a_3, \ldots\ldots a_n$.

$a_{mean} = (a_1 + a_2 + a_3 + \ldots\ldots + a_n)/n$

$\therefore a_{mean} = \sum_{i=1}^{n} \frac{a_i}{n}$ if n>8, result is reasonably correct.

Uncertainty: S.D.: $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(a_i - \bar{a})^2}$

i. **Absolute Error:** absolute value of the difference between a_i and a_{mean}.:

$\Delta a_1 = a_1 - a_{mean}$; $\Delta a_2 = a_2 - a_{mean}$ $\Delta a_3 = a_3 - a_{mean}$ ..... $\Delta a_n = a_n - a_{mean}$

Δa can be positive or negative but $|\Delta a|$ is always positive.

Mean absolute error: $\Delta a_{mean} = \left(\frac{|\Delta a_1| + |\Delta a_2| + \cdots + |\Delta a_n|}{n}\right) = \frac{\sum_{i=1}^{n}|\Delta a_i|}{n}$

$\therefore$ a is likely to lie between $(a_{mean} + \Delta a_{mean})$ and $(a_{mean} - \Delta a_{mean})$

i.e., $(a_{mean} - \Delta a_{mean}) \le a \le (a_{mean} + \Delta a_{mean})$

ii. **Relative Error:** Relative error is the ratio of the mean absolute error, Δa_{mean} to the mean value, a_{mean} of the quantity measured.

Relative Error = $\frac{\Delta a_{mean}}{a_{mean}}$

iii. **Percentage Error:** When the relative error is expressed in percent, it is called the percentage error.

Percentage error, $\delta a = \frac{\Delta a_{mean}}{a_{mean}} \times 100\%$

12. COMBINATION OF ERRORS:

i. X = a + b

⇨ $X \pm \Delta X = (a \pm \Delta a) + (b \pm \Delta b) = (a + b) + (\pm \Delta a \pm \Delta b)$

⇨ $\pm \Delta X = \pm \Delta a \pm \Delta b = \pm (\Delta a + \Delta b)$

ii. **X = a - b**

⇨ $X \pm \Delta X = (a \pm \Delta a) + (b \pm \Delta b) = (a + b) - (\pm \Delta a \pm \Delta b)$

⇨ $\pm \Delta X = \pm \Delta a - \Delta b = \pm (\Delta a + \Delta b)$

iii. X = a x b

$X \pm \Delta X = (a \pm \Delta a)(b \pm \Delta b)$

$= ab \pm a\,\Delta b \pm b\,\Delta a \pm \Delta a\,\Delta b$

Dividing L.H.S. by X and R.H.S by ab, we get

$$1 \pm \frac{\Delta x}{x} = 1 \pm \frac{\Delta b}{b} \pm \frac{\Delta a}{a} \pm \frac{\Delta a \Delta b}{ab}$$

$$\pm \frac{\Delta x}{x} = \pm \frac{\Delta a}{a} \pm \frac{\Delta b}{b}$$

iv. X = a/b

$$x \pm \Delta x = \frac{a \pm \Delta a}{b \pm \Delta b}$$

$$x\left(1 \pm \frac{\Delta x}{x}\right) = \frac{a\left(1 \pm \frac{\Delta a}{a}\right)}{b\left(\frac{1 \pm \Delta b}{b}\right)}$$

$$1 \pm \frac{\Delta x}{x} = \left(1 \pm \frac{\Delta a}{a}\right)\left(1 \pm \frac{\Delta b}{b}\right)^{-1}$$

$$1 \pm \frac{\Delta x}{x} = \left(1 \pm \frac{\Delta a}{a}\right)\left(1 \mp \frac{\Delta b}{b}\right)$$

$$1 \pm \frac{\Delta x}{x} = 1 \pm \frac{\Delta b}{b} \pm \frac{\Delta a}{a} \pm \frac{\Delta a \Delta b}{ab}$$

$$\pm \frac{\Delta x}{x} = \pm \frac{\Delta a}{a} \pm \frac{\Delta b}{b}$$

13. SIGNIFICANT FIGURES: 10.46: 4 significant digits: 1- most significant, 6- least significant

a) **Rules:**

i. Non-zero digits: 1234 – 4 significant digits

ii. Zeros b/w two non- zero digit: 1007--4 significant digits

iii. n < 1: 0.0084—2 significant digits

iv. 0.00800 => 3 significant digits

v. zeros on the right of a non-zero digit: not significant: 1000—1 significant digit

vi. zeros on the right of the last non-zero digit: significant when come from measurement. e.g., 3050 m= 3.050 Km = 3.050 x 10^5 cm—4 significant digits.

vii. Depends upon the least count of the instrument:

X = 0.428 m

ΔX = 0.001

Maximum Error = + 0.001

% Error = $\frac{0.001}{0.428} \times 100$

14. Order of magnitude: The order of magnitude of a physical quantity is the value of its magnitude rounded off to the nearest integral power of 10.

a. 123 kg = 1.23×10^2 kg.
The number before decimal is less than five, hence the order of magnitude is 10^2 kg.

b. 6527 km = 6.527×10^3 km
The number before decimal is 5 or more than 5 then, the order of magnitude = 10^{3+1} km = 10^4 km.

Note: it is customary to write decimal after the first digit. E.g., 226.4cm = 2.26 x 10^2 cm

15. Rules in calculation:

i. + & - : In both addition and subtraction, the final result should retain as many decimal places as are there in the number with smallest number of decimal places.

ADDITION

123.1	**+**	**23**	**=**	**146**
1 d.p.		**0 d.p.**		**0 d.p.**

SUBTRACTION

123.1	**-**	**23**	**=**	**100**
1 d.p.		**0 d.p.**		**0 d.p.**

ii. x & ÷: Final answer is only as precise as the value with the least number of significant figures.

MULTIPLICATION

123.1	**x**	**23**	**=**	**2800**
4 s.f.		**2 s.f.**		**2 s.f.**

DIVISION

123.1	**÷**	**23**	**=**	**5.4**
4 s.f.		**2 s.f.**		**2 s.f.**

16. Rounding off:

i.	2.746	6>5	rounded off to 2.75	iii.	2.745	4-even	rounded off to 2.74
ii.	2.743	3<5	rounded off to 2.74	iv.	2.795	9-odd	rounded off to 2.8

17. DIMENSIONAL FORMULAE AND DIMENSIONAL EQUATIONS:

For dimensional formulae of physical quantities: Refer NCERT

DIMENSIONAL ANALYSIS AND ITS APPLICATIONS:

i. **Principle of Homogeneity of Dimensions:** Only those physical quantities can be added or subtracted which have the same dimensions.

ii. **Applications of Dimensions:**

a) To check the dimensional consistency of equations.

b) To deduce a relation between different physical quantities.

c) To convert one system of unit into another system.

TO CONVERT A PHYSICAL QUANTITY FROM ONE SYSTEM OF UNITS TO ANOTHER---

The magnitude of a physical quantity remains the same whatever may be the system of units

G - $n_1U_1 = n_2U_2$

Dimensional formulae of quantity Q be $M^aL^bT^c$ then

$n_1[M_1{}^aL_1{}^bT_1{}^c] = n_2[M_2{}^aL_2{}^bT_2{}^c]$

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

LIMITATIONS OF DIMENSIONAL ANALYSIS METHOD:

- Dimensionless quantities cannot be determined by this method.
- Constant of proportionality cannot be determined by this method. They can be found either by experiment or by theory.
- This method is not applicable to derive trigonometric, logarithmic and exponential functions.
- In the case of physical quantities which depend upon more than three physical quantities, this method will be difficult to obtain physical equation.
- The proportionality constants cannot be obtained from this method.
- If either side of equation contains addition or subtraction of physical quantities, we cannot use this method to obtain physical equation.

VERNIER CALLIPERS: Vernier Calipers was designed by Pierre Vernier. It is used to measure small lengths of solid objects, to measure 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.

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;

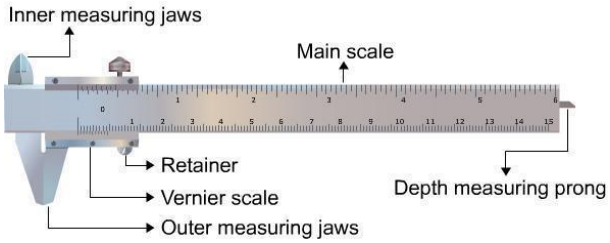
If the zero of the vernier scale lies ahead of the Nth division of the main scale, then the main scale reading (MSR) is N

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,

$TR = MSR + VSR = N + (n \times L.C) \ldots\ldots\ldots (2)$



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18. SCREW GUAGE:

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

= 1 mm

Number of divisions on 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

n: Number of circular division coinciding