DAY 1

Physics & Measurement

OUTLINES

1. Units
2. Least count
3. Significant Figures
4. Errors in Measurement
5. Dimensions of Physical Quantities

Units

Measurement of any physical quantity involves comparison with a certain basic, widely accepted reference standard called unit.

Fundamental *and* Derived Units

The number of physical quantities is quite large. Thus, we may define a set of **fundamental** (or base) quantities and all other quantities may be expressed in terms of these fundamental quantities. All other quantities are **derived quantities**.

Units of fundamental and derived quantities are known as the **fundamental units** and **derived units** respectively. A complete set of these units, both fundamental and derived unit is known as the **system of units**.

System of Units

International System of Units It is abbreviated as SI, is an extended version of the MKS (Metre, Kilogram, Second) system. SI system of units has seven base units and two supplementary units. Seven base quantities, their units along with definitions are tabulated ahead.

This system measures, Length in metre (m), Mass in kilogram (kg), Time in second (s).

The two supplementary units in SI system are

Radian for angle It is the angle subtended at the centre by an arc of a circle having a length equal to the radius of the circle. Its symbol is rad.

Steradian for solid angle It is the solid angle which is having its vertex at the centre of the sphere, it cuts-off an area of the surface of sphere equal to that of a square with the length of each side equal to the radius of the sphere.

- *Angle subtended by a closed curve at an inside points is 2π rad.*
- *Solid angle subtended by a closed surface at an inside point is 4π steradian.*

There are two systems used in units can be defined as

CGS System (Centimetre, Gram, Second) are often used in scientific work.

This system measures, Length in centimetre (cm), Mass in gram (g), Time in second (s).

FPS System (Foot, Pound, Second). It is also called the British Unit System. This unit measures, Length in foot (foot), Mass in gram (pound), Time in second (s).

Base Quantity	SI Units	
	Name and Symbol	Definition
Length	metre (m)	The metre is the length of path travelled by light in vacuum during a time interval of 1/299, 792, 458 part of a second.
Mass	kilogram (kg)	It is the mass of the international prototype of the kilogram (a platinum iridium alloy cylinder) kept at International Bureau of Weights and Measures, at Sevres (France)
Time	second (s)	The second is the duration of 9, 192, 631, 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of cesium – 133 atom.
Electric current	Ampere (A)	The Ampere is that constant current, which if maintained in two straight, parallel conductors of infinite length placed 1 m apart in vacuum would produce a force equal to 2×10^{-7} Nm^{-1} on either conductor.
Thermodynamic temperature	Kelvin (K)	The Kelvin is $\frac{1}{273.16}$ th fraction of the thermodynamic temperature of the triple point of water.
Amount of substance	mole (mol)	The mole is the amount of substance of a system, which contains as many elementary entities as there are atoms in 0.012 kg of carbon –12.
Luminous intensity	candela (cd)	The candela is the luminous intensity in a given direction of a source emitting monochromatic radiation of frequency 540×10^{12} Hz and having a radiant intensity of $\frac{1}{683}$ W sr^{-1} in that direction.

Least Count

The least count of a measuring device is the least distance (resolution/accuracy), that can be measured using the device. The general formula that can be used for Least Count (LC).

$$LC = \frac{\text{Value of 1 main scale division}}{\text{Total number of vernier scale divisions}}$$

Every measuring instrument has no error, when readings are taken. The least count uncertainity or maximum possible error characterises such errors. Instruments error can be compared by calculating the percentage of uncertainity of their readings. The instrument with the least uncertainity is taken to measure objects, as all measurements consider accuracy. *The percentage uncertainity is calculated with the following formula*

$$\text{Percentage Uncertainity} = \frac{\text{Maximum possible error}}{\text{Measurement of object in question}} \times 100$$

The smaller the measurement, the larger the percentage uncertainity. The least count of an instrument is indirectly proportional to the precision of the instrument.

Least Count of Certain Measuring Instruments

- Vernier calliper,

  $$\text{Least count} = \frac{1\text{ mm}}{10\text{ divisions}} = 0.1\text{ mm}$$

- Screw gauge,

  Least count

  $$= \frac{\text{Value of 1 pitch scale reading}}{\text{Total number of head scale divisions}}$$

  $$\text{Least count} = \frac{1\text{ mm}}{100\text{ divisions}}$$

  $$= 0.01\text{ mm}$$

- Travelling microscope,

  Least count

  $$= \frac{\text{Value of 1 main scale division}}{\text{Total number of vernier scale divisions}}$$

  $$= \frac{0.5\text{ mm}}{50\text{ divisions}} = 0.01\text{ mm}$$

- Spectrometer,

  $$\text{Least count} = \frac{0.5\text{ degree}}{30\text{ divisions}}$$

  $$= \frac{30'}{30\text{ divisions}} = 1'$$

  1 degree (angle) = $60'$ and $1' = 60''$

Least Count Error

Measured values are good only upto its least count. The least count error is the error associated with the resolution of the instrument.

Least count error belongs to the category of random errors but within a limited scale, it occurs with both systematic and random errors. If we use a metre scale for measurement of length, it may have graduations as 1 mm division scale spacing or interval. Instruments of higher precision, improving experimental techniques etc., can reduce the least count error. Repeating the observations and taking the arithmetic mean of the result, the mean value would be very close to the true value of the measured quantity.

Significant Figures

Significant figure in the measured value of a physical quantity tells the number of digits in which we have confidence. All accurately known digits in a measurement plus the first (only one uncertain digit together in a measured value form significant figures). Larger the number of significant figures obtained in a measurement, greater is the accuracy of the measurement.

Rules for Counting Significant Figures

1. All the non-zero digits are significant. In 2.738 the number of significant figures is 4.
2. All the zeros between two non-zero digits are significant, no matter where the decimal point is, if at all. As examples 209 and 3.002 have 3 and 4 significant figures respectively.
3. If the measurement number is less than 1, the zero (s) on the right of decimal point and to the left of the first non-zero digit are non-significant. In $\underline{0}\,.\underline{00}807$, first three underlined zeros are non-significant and the number of significant figures is only 3.
4. The terminal or trailing zero (s) in a number without a decimal point are not significant. Thus, 12.3 = 1230 cm = 12300 mm has only 3 significant figures.
5. The trailing zero (s) in number with a decimal point are significant. Thus, 3.800 kg has 4 significant figures.
6. A choice of change of units does not change the number of significant digits or figures in a measurement.

Rules for Arithmetic Operations with Significant Figures

1. In addition or subtraction, the final results should retain as many decimal places as there are in the number with the least decimal place. As an example sum of 423.5 g, 164.92 g and 24.381 g is 612.801 g, but it should be expressed as 612.8 g only because the least precise measurement (423.5 g) is correct to only one decimal place.
2. In multiplication or division, the final result should retain as many significant figures as are there in the original number with the least significant figures. For example Suppose an expression is performed like

   $$(24.3 \times 1243) / (44.65) = 676.481522$$

   Rounding the above result upto three significant figures result would become 676.

Rules for Rounding off the Uncertain Digits

Result of arithmetic computation we get a number having more digits than the appropriate number of significant figures, then these uncertain digits are rounded off as per the rules given ahead

(i) The preceding digit is raised by 1 if the insignificant digit to be dropped is more than 5 and is left unchanged if the latter is less than 5.

e.g., 18.764 will be rounded off to 18.8 and 18.74 to 18.7.

(ii) If the insignificant figure is 5 and the preceding digit is even, then the insignificant digit is simply dropped. However, if the preceding digit is odd, then it is raised by one so as to make it even. *e.g.*, 17.845 will be rounded off to 17.84 and 17.875 to 17.88

Errors in Measurement

There are many causes of errors in measurement. Errors may be due to instrumental defects, ignoring certain facts, carelessness of experimenter, random change in temperature, pressure, humidity, etc. When an experimenter tries to reach accurate value of measurement by doing large number of experiments, the mean of a large number of the results of repeated experiments is close to the true value.

The result of every measurement contains some uncertainty, which is called **error**.

(i) True value

$$a_{true} = a_{mean} = a_0 = \frac{a_1 + a_2 + a_3 + \dots a_n}{n} = \frac{1}{n}\sum_{i=1}^{i=n} a_i$$

(ii) Absolute error

Δa_1 = true value − observed value

$$\Delta a_1 = a_0 - a_1$$
$$\Delta a_2 = a_0 - a_2$$
$$\vdots \quad \vdots \quad \vdots$$
$$\Delta a_n = a_0 - a_n$$

(iii) Mean absolute error

$$\Delta a_{mean} = \frac{[|\Delta a_1| + |\Delta a_2| + |\Delta a_3| + \dots + |\Delta a_n|]}{n} = \frac{\sum_{i=1}^{n} |\Delta a_i|}{n}$$

(iv) Relative or fractional error $= \dfrac{\Delta a_{mean}}{a_{mean}}$

(v) Percentage error δ_a = Relative error × 100 %

$$= \frac{\Delta a_{mean}}{a_{mean}} \times 100\%$$

Combination of Errors

1. When two (or more) quantities are added or subtracted, the maximum possible absolute error in the final result is the sum of the absolute errors in the individual quantities.

   If $X = A + B$, then $(\Delta X)_{max} = \pm(\Delta A + \Delta B)$

2. When two (or more) quantities are multiplied or divided, the maximum relative error in the result is the sum of the individual relative errors in the multipliers.

   If $X = ABC$, then $\left(\dfrac{\Delta X}{X}\right)_{max} = \pm\left[\dfrac{\Delta A}{A} + \dfrac{\Delta B}{B} + \dfrac{\Delta C}{C}\right]$

3. The maximum relative error due to a physical quantity raised to a certain power (say k) is k times the relative error in that physical quantity. As an example, if $Z = A^k B^l C^n$

   Then, $\left(\dfrac{\Delta Z}{Z}\right)_{max} = \pm\left[k\dfrac{\Delta A}{A} + l\dfrac{\Delta B}{B} + n\dfrac{\Delta C}{C}\right]$

Dimensions of Physical Quantities

The dimensions of a physical quantity are the powers to which the fundamental (base) quantities are raised, to represent that quantity.

To make it clear, consider the physical quantity force.

Force = mass × acceleration

= mass × length × $(\text{time})^{-2}$

Thus, the dimension of force are 1 in mass [M] 1 in length [L] and −2 in time $[T^{-2}]$, that is $[MLT^{-2}]$

- *Dimensions of a physical quantity do not depend on its magnitude or the units in which it is measured.*
- *Dimensional analysis/equation can be used for the conversion of units i.e., From FPS to CGS and so on.*
- *Dimensional formula and SI unit of some physical quantities commonly used in physics are given on the next page.*

Principle of Homogeneity of Dimensions and Applications

According to this principle, a correct dimensional equation must be homogeneous, *i.e.*, dimensions of all the terms in a physical expression must be same.

LHS = RHS

Dimensional analysis can be used in conversion of units, to check the dimensional correctness of physical relation and to establish relation among various physical quantities.

Limitations of Theory of Dimensions

Although dimensional analysis is very useful but it is not universal, it has some limitations as given below

- This method gives no information about dimensional constants. Such as universal constant of gravitation (G) or Planck's constant (h) and where they have to be introduced.
- Numerical constant (k), having no dimensions such as 3/4, e, 2π etc., cannot be deduced by the method of dimensions.
- This technique is useful only for deducing and verifying power relations. Relationship involving exponential, trignometric functions etc., cannot be obtained or studied by this technique.
- In this method, we compare the powers of fundamental quantities (like M,L,T etc.,) to obtain a numbers of independent equations to find the unknown powers. Since, the total number of such equations cannot exceed the number of fundamental quantities we cannot use this method to obtain the required relation if the quantity of interest depends upon more parameters than the number of fundamental quantities used.
- Even if a physical quantity depends on three physical quantities, out of which two have same dimensions, the formula cannot be derived by theory of dimensions.

- *The physical quantities separated by the symbols +, −, =, >, < etc., must have the same dimensions.*
- *In thermodynamics, physical dimensions of pV, $RTmc$, ΔT, mL, ΔQ, ΔU, ΔW, etc., are same as that of energy, i.e.,* $[ML^2T^{-2}]$
- *In electrical circuits, dimensions of $\frac{L}{R}$, RC, $\sqrt{LC}$ have the dimensions of time.*
- *Even if units and dimensions of two physical quantities are same, they need not represent the same physical characteristics, e.g., work and torque or angular momentum and Planck's constant or gravitational intensity and acceleration, etc.*

Values of Some Physical Quantities

Physical Quantity	Symbol	Value	Physical Quantity	Symbol	Value
Speed of light	c	3×10^8 ms^{-1}	Bohr radius	r_B	0.053 nm
Charge of electron	e	-1.6×10^{-19} C	Molar volume	V	22.4 litre/mol
Mass of electron	m_e	9.1×10^{-31} kg	Permittivity of free space	ε_0	8.85×10^{-12} Fm^{-1}
Mass of proton	m_p	1.672×10^{-27} kg	Permeability of free space	μ_0	$4\pi\times10^{-7}$ Hm^{-1}
Mass of neutron	m_n	1.674×10^{-27} kg	Wien's constant	b	2.9×10^{-3} mK
Planck's constant	h	6.63×10^{-34} Js	Mechanical equivalent of heat	J	4.2 J/cal
Universal gas constant	R	8.3 J/mol-K	Density of air at STP	ρ_a	1.293 kgm^{-3}
Boltzmann's constant	k	1.3×10^{-23} JK^{-1}	Latent heat of ice	L_{ice}	80 calg^{-1}
Stefan's constant	σ	5.67×10^{-8} W/m^2 K^4	Latent heat of steam	L_{steam}	540 calg^{-1}
Gravitational constant	G	6.67×10^{-11} Nm^{2}kg^{-2}			

Dimensions of Important Physical Quantities

Physical Quantity	SI Unit	Dimensional Formula
Power	Watt (W)	$[ML^2T^{-3}]$
Pressure, stress, coefficient of elasticity (Y, B, η)	Pascal (Pa) or Nm^{-2}	$[ML^{-1}T^{-2}]$
Angular velocity	rad s^{-1}	$[T^{-1}]$
Frequency, angular frequency	Hz or s^{-1}	$[T^{-1}]$
Angular acceleration	rad s^{-2}	$[T^{-2}]$
Angular momentum	kg m^{2}s^{-1}	$[ML^2T^{-1}]$
Torque	N-m (or J)	$[ML^2T^{-2}]$
Gravitational constant (G)	Nm^{2}kg^{-2}	$[M^{-1}L^3T^{-2}]$
Moment of inertia	kg-m^2	$[ML^2]$

Physical Quantity	SI Unit	Dimensional Formula
Electric field intensity	NC^{-1} or Vm^{-1}	$[MLT^{-3}A^{-1}]$
Electric potential, emf, potential difference	JC^{-1} or volt (V)	$[ML^2T^{-2}A^{-1}]$
Electric dipole moment	C-m	$[LTA]$
Electric flux	Nm^2C^{-1} or Vm	$[ML^3T^{-3}A^{-1}]$
Capacitance	Farad (F)	$[M^{-1}L^{-2}T^4A^2]$
Resistance, reactance, impedance	Ohm (Ω)	$[ML^2T^{-3}A^{-2}]$
Resistivity	Ω-m	$[ML^3T^{-3}A^2]$
Length, distance, displacement, wavelength	metre (m)	$[L]$ or $[M^0LT^0]$
Volume	m^3	$[L^3]$ or $[M^0L^3T^0]$
Density	$kg\,m^{-3}$	$[ML^{-3}]$
Speed, velocity	ms^{-1}	$[LT^{-1}]$
Acceleration, acceleration due to gravity	ms^{-2}	$[LT^{-2}]$
Force, thrust, tension, weight	Newton (N)	$[MLT^{-2}]$
Linear momentum, impulse	$kg\,ms^{-1}$ or N-s	$[MLT^{-1}]$
Work, energy, KE, PE, thermal energy, internal energy, etc.	Joule (J)	$[ML^2T^{-2}]$
Surface area, area of cross-section	m^2	$[L^2]$
Electric conductivity	Sm^{-1}	$[M^{-1}L^{-3}T^3A^2]$
Inductance	Henry (H)	$[ML^2T^{-2}A^{-2}]$
Magnetic charge or magnetic pole strength	A-m	$[LA]$
Magnetic dipole moment	A-m^2	$[LA^2]$
Magnetic field or magnetic flux density or magnetic induction	Tesla (T) or Wbm^{-2}	$[MT^{-2}A^{-1}]$
Magnetic permeability of free space or a medium	Hm^{-1}	$[MLT^{-2}A^{-2}]$
Magnetic flux	Weber (Wb)	$[ML^2T^{-2}A^{-1}]$
Volumetric flow rate	m^3s^{-1}	$[L^3T^{-1}]$
Radius of gyration	m	$[L]$
Young's modulus, Bulk modulus	Pa	$[ML^{-1}T^{-2}]$
Compressibility	m^2N^{-1}	$[M^{-1}LT^{-2}]$
Flux	W	$[ML^2T^{-3}]$
Flux density	Wm^{-2}	$[MT^{-3}]$
Intensity of a wave	Wm^{-2}	$[MT^{-3}]$
Light radiation flux	W	$[ML^2T^{-3}]$
Photon flux density	$m^{-2}s^{-1}$	$[L^{-2}T^{-1}]$
Luminous energy	Lm-s	$[ML^2T^{-2}]$
Luminance	Lx	$[MT^{-3}]$
Radiation intensity	Watt-Steradian	$[ML^2T^{-3}]$
Specific heat capacity	$Jkg^{-1}K^{-1}$	$[L^2T^{-2}K^{-1}]$
Latent heat of vaporisation	Jkg^{-1}	$[L^2T^{-2}]$
Thermal conductivity	Ks^{-1}	$[MLT^{-3}K^{-1}]$
Emissive power	Wm^{-2}	$[MT^{-3}]$
Electric voltage	JC^{-1}	$[ML^2T^{-3}A^{-1}]$
Magnetisation	Am^{-1}	$[L^{-1}A]$
Magnetic induction	T	$[MT^{-2}A^{-1}]$
Electrochemical equivalent	kgC^{-1}	$[MT^{-1}A^{-1}]$
Planck's constant	Js	$[ML^2T^{-1}]$
Work function	J	$[ML^2T^{-2}]$
Radioactive decay Constant	Bq	$[T^{-1}]$
Binding Energy	MeV	$[ML^2T^{-2}]$

1. In the relation $X = 3YZ^2$, X and Z represent the dimensions of capacitance and magnetic induction respectively, dimensions of Y are

(a) $[MT^{-1}Q^{-1}]$
(b) $[M^{-3}T^4L^{-2}Q^4]$
(c) $[M^{-3}T^{-1}L^{-1}Q^4]$
(d) $[ML^2T^{-2}A^{-2}]$

2. The velocity of a particle is given as $v = a + bt + ct^2$. If the velocity is measured in ms^{-1}, then units of a and c are

(a) ms^{-1} and ms^{-3}
(b) ms^{-2} and m-s
(c) m^2s^{-1} and ms^2
(d) m-s and ms^{-1}

3. In which of the following systems of units, a weber is the unit of magnetic flux?

(a) CGS
(b) MKS
(c) SI
(d) None of these

4. With the usual notations, the following equation

$$s_t = u + \frac{1}{2}a(2t - 1) \text{ is}$$

(a) only numerically correct
(b) only dimensionally correct
(c) Both numerically and dimensionally correct
(d) Neither numerically nor dimensionally correct

5. If the velocity of light c, gravitational constant G and Planck's constant h are chosen as fundamental units, the dimensions of length L in the new system are

(a) $[hcG^{-1}]$
(b) $[h^{1/2}c^{1/2}G^{-1/2}]$
(c) $[hc^{-4}G]$
(d) $[h^{1/2}c^{-3/2}G^{1/2}]$

6. Using mass (M), length (L), time (T) and current (A) as fundamental quantities, the dimensions of magnetic permeability are

(a) $[M^{-1}LT^{-2}A]$
(b) $[ML^2T^{-2}A^{-1}]$
(c) $[MLT^{-2}A^{-2}]$
(d) $[MLT^{-1}A^{-1}]$

7. The dimensions of $\frac{e^2}{4\pi\varepsilon_0 hc}$, where e, ε_0, h and c are the electronic charge, electric permittivity, Planck's constant and velocity of light in vacuum respectively, are

(a) $[M^0L^0T^0]$
(b) $[ML^0T^0]$
(c) $[M^0LT^0]$
(d) $[M^0L^0T]$

8. If Planck's constant (h_1) and speed of light in vaccum (c) are taken as two fundamental quantities, which one of the following can, in addition,be taken to express length, mass and time in terms of the three chosen fundamental quantities? **[NCERT Exemplar]**

(a) Mass of electron (m_e)
(b) Universal gravitational constant (G)
(c) Charge of electron (e)
(d) Mass of proton (m_p)

9. If the acceleration due to gravity is $10\ ms^{-2}$ and units of length and time are changed to kilometre and hours respectively, the numerical value of acceleration is

(a) 360000
(b) 72000
(c) 36000
(d) 129600

10. If E = energy, G = gravitational constant, I = impulse and M = mass, then dimensions of $\frac{GIM^2}{E^2}$ are same as that of

(a) time
(b) mass
(c) length
(d) force

11. You measure two quantities as $A = 1.0\ m \pm 0.2\ m$, $B = 2.0\ m \pm 0.2\ m$. We should report correct value for $\sqrt{AB}$ as **[NCERT Exemplar]**

(a) $1.4\ m \pm 0.4\ m$
(b) $1.41\ m \pm 0.15\ m$
(c) $1.4\ m \pm 0.3\ m$
(d) $1.4\ m \pm 0.2\ m$

12. The speed (v) of ripples on the surface of water depends on surface tension (σ), density (ρ) and wavelength (λ). The square of speed (v) is proportional to

(a) $\frac{\sigma}{\rho\lambda}$
(b) $\frac{\rho}{\sigma\lambda}$
(c) $\frac{\lambda}{\sigma\rho}$
(d) $\rho\lambda\sigma$

13. Dimensions of resistance in an electrical circuit, in terms of dimensions of mass M, length L, time T and current I, would be

(a) $[ML^2T^{-3}I^{-1}]$
(b) $[ML^2T^{-2}]$
(c) $[ML^2T^{-1}I^{-1}]$
(d) $[ML^2T^{-3}I^{-2}]$

14. A sphere has a mass of $12.2\ kg \pm 0.1\ kg$ and radius $10\ cm \pm 0.1\ cm$, the maximum % error in density is

(a) 10%
(b) 2.4%
(c) 3.83%
(d) 4.2%

15. In the relation $p = \frac{\alpha}{\beta} e^{-\frac{\alpha z}{k\theta}}$, p is pressure, z is distance, k is Boltzmann constant and θ is the temperature. The dimensional formula of β will be

(a) $[M^0L^2T^0]$ (b) $[ML^2T]$
(c) $[ML^0T^{-1}]$ (d) $[M^0L^2T^{-1}]$

16. N division on main scale of a vernier callipers coincide with $(N+1)$ division of the vernier scale if each division on main scale is of a units, least count of instrument is

(a) $\frac{N+1}{a}$ (b) $\frac{a}{N+1}$
(c) $\frac{N-1}{a}$ (d) $\frac{a}{N-1}$

17. If the length of rod A is 3.25 ± 0.01 cm and that of B is $4.19 + 0.01$ cm, then the rod B is longer than rod A by

(a) (0.94 ± 0.00) cm (b) (0.94 ± 0.01) cm
(c) (0.94 ± 0.02) cm (d) (0.094 ± 0.005) cm

18. A student measured the length of the pendulum 1.21 m using a metre scale and time for 25 vibrations as 2 min 20 using his wrist watch, absolute error in g is

(a) 0.11 ms^{-2} (b) 0.88 ms^{-2}
(c) 0.44 ms^{-2} (d) 0.22 ms^{-2}

19. If error in measurement of radius of sphere is 1%, what will be the error in measurement of volume?

(a) 1% (b) $\frac{1}{3}$%
(c) 3% (d) 10%

20. The dimensions of σb^4 (σ = Stefan's constant and b = Wien's constant) are

(a) $[M^0L^0T^0]$ (b) $[ML^4T^{-3}]$
(c) $[ML^{-2}T]$ (d) $[ML^6T^{-3}]$

21. The absolute error in density of a sphere of radius 10.01 cm and mass 4.692 kg is

(a) 3.97 kgm^{-3} (b) 4.692 kgm^{-3}
(c) 0 (d) 1.12 kgm^{-3}

22. The dimensions of $\frac{a}{b}$ in the equation $p = \frac{a - t^2}{bx}$ where p is pressure, x is distance and t is time, are

(a) $[M^2LT^{-3}]$ (b) $[MT^{-2}]$
(c) $[ML^3T^{-2}]$ (d) $[LT^{-3}]$

23. The length and breadth of a rectangular sheet are 16.2 cm and 10.1 cm, respectively. The area of the sheet in appropriate significant figures and error is **[NCERT Exemplar]**

(a) $164 \pm 3\,cm^2$ (b) $163.62 \pm 2.6\,cm^2$
(c) $163.6 \pm 2.6\,cm^2$ (d) $163.62 \pm 3\,cm^2$

24. The position of a particle is given by

$$x = a \sin \omega t$$
$$y = a \cos \omega t$$

The trajectory of the path is a

(a) hyperbola (b) straight line
(c) point (d) parabola

25. In the following dimensionally consistent equation, we have, $F = \frac{X}{\text{Linear density}} + Y$, where F = force.

The dimensional formula for X and Y are

(a) $[M^2L^0T^{-2}]$; $[MLT^{-2}]$ (b) $[M^2L^{-2}T^{-2}]$; $[MLT^{-2}]$
(c) $[MLT^{-2}]$; $[ML^2T^{-2}]$ (d) $[M^0L^0T^0]$; $[ML^0T^0]$

26. The dimensions of self-inductance are

(a) $[ML^{-2}T^{-2}I^{-2}]$ (b) $[ML^2T^{-2}I^{-2}]$
(c) $[ML^2T^{-2}I^{-1}]$ (d) $[ML^{-2}T^{-2}I^{-1}]$

27. What is the percentage error in the measurement of the time period T of a pendulum, if the maximum errors in the measurements of l and g are 2% and 4% respectively?

(a) 6% (b) 4%
(c) 3% (d) 5%

28. One 8 centimetre on the main scale of a vernier calliper is divided into 10 equal parts. If 10 of the divisions of the vernier coincide with small divisions on the main scale, the least count of the callipers is

(a) 0.005 cm (b) 0.02 cm
(c) 0.01 cm (d) 0.05 cm

Directions *(Q. Nos. 29 to 34) Each of these questions contains two statements : Statement I (Assertion) and Statement II (Reason). Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c), (d) given below*

(a) Statement I is true, Statement II is true; Statement II is the correct explanation for Statement I
(b) Statement I is true, Statement II is true; Statement II is not the correct explanation for Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

29. Statement I The order of accuracy of measurement depends on the least count of the measuring instrument.

Statement II The smaller the least count, the greater is the number of significant figures in the measured value.

30. Statement I The dimensional method cannot be used to obtain the dependence of the work done by a force F on the angle θ between force F and displacement x.

Statement II All trigonometric functions are dimensionless.

31. **Statement I** The mass of an object is 13.2 kg. In this measurement there are 3 significant figures.

Statement II The same mass when expressed in grams as 13200 g, has five significant figures.

32. **Statement I** Method of dimensions cannot be used for deriving formula containing trigonometrical ratios.

Statement II This is because trigonometrical ratios have no dimensions.

33. **Statement I** The value of velocity of light is 3×10^8 ms^{-1} and acceleration due to gravity is 10 ms^{-2} and the mass of proton is 1.67×10^{-27} kg.

Statement II The value of time in such a system is 3×10^7 s.

34. **Statement I** The distance covered by a body is given by

$S = u + \frac{1}{2}\frac{a}{t}$, where the symbols have usual meaning.

Statement II We add quantities, substract or equate quantities with the same dimensions.

Directions (Q. Nos. 35 to 37) *In the study of physics, we often have to measure the physical quantities. The numerical value of a measured quantity can only be approximately depends upon the least count of the measuring instrument used. The number of significant figures in any measurement indicates the degree of precision of that measurement. The importance of significant figures lies in calculation. A mathematical calculation cannot increase the precision of a physical measurement. Therefore, the number of significant figures in the sum or product of a group of numbers cannot be greater than the number that has the least number of significant figures. A chain cannot be stronger than its weakest link.*

35. A bee of mass 0.000087 kg sits on a flower of mass 0.0123 kg. What is the total mass supported by the stem of the flower up to appropriate significant figures?

(a) 0.012387 kg (b) 0.01239 kg
(c) 0.0124 kg (d) 0.012 kg

36. The radius of a uniform wire is $r = -$ 0.021 cm. The value of π is given to be 3.142. What is the area of cross-section of the wire up to appropriate significant figures?

(a) 0.0014 cm^2 (b) 0.00139 cm^2
(c) 0.001386 cm^2 (d) 0.0013856 cm^2

37. A man runs 100.5 m in 10.3 s. Find his average speed up to appropriate significant figures.

(a) 9.71 ms^{-1} (b) 9.708 ms^{-1}
(c) 9.7087 ms^{-1} (d) 9.70874 ms^{-1}

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38. The dimensions of angular momentum, latent heat and capacitance are, respectively. **[JEE Main Online 2013]**

(a) $[ML^2T^1A^2]$, $[L^2T^{-2}]$, $[M^{-1}L^{-2}T^2]$
(b) $[ML^2T^{-2}]$, $[L^2T^2]$, $[M^{-1}L^{-2}T^4A^2]$
(c) $[ML^2T^{-1}]$, $[L^2T^{-2}]$, $[ML^2TA^2]$
(d) $[ML^2T^{-1}]$, $[L^2T^{-2}]$, $[M^{-1}L^{-2}T^4A^2]$

39. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is **[AIEEE 2012]**

(a) 6% (b) zero
(c) 1% (d) 3%

40. A screw gauge gives the following reading when used to measure the diameter of a wire. **[AIEEE 2011]**

Main scale reading : 0 mm
Circular scale reading : 52 divisions
Given that 1 mm on main scale corresponds to 100 divisions of the circular scale.
The diameter of wire from the above data is

(a) 0.052 cm (b) 0.026 cm
(c) 0.005 cm (d) 0.52 cm

41. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are **[AIEEE 2010]**

(a) 5, 1, 2 (b) 5, 1, 5 (c) 5, 5, 2 (d) 4, 4, 2

42. In an experiment the angles are required to be measured using an instrument. 29 divisions of the vernier scale. If the smallest division of the main scale is half-a-degree (= 0.5°), then the least count of the instrument is **[AIEEE 2009]**

(a) one minute (b) half minute
(c) one degree (d) half degree

43. The dimensions of magnetic field in M,L,T and C (Coulomb) is given as **[AIEEE 2008]**

(a) $[MLT^{-1}C^{-1}]$ (b) $[MT^2C^{-2}]$ (c) $[MT^{-1}C^{-1}]$ (d) $[MT^{-2}C^{-1}]$

44. Two full turns of the circular scale of a screw gauge cover a distance of 1 mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of – 0.03 mm while measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is **[AIEEE 2008]**

(a) 3.32 mm (b) 3.73 mm
(c) 3.67 mm (d) 3.38 mm

45. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distance are measured by **[AIEEE 2008]**

(a) a vernier scale provided on the microscope
(b) a standard laboratory scale
(c) a meter scale provided on the microscope
(d) a screw gauge provided on the microscope

46. Which of the following sets share different dimensions?

(a) Pressure, Young's modulus, stress **[AIEEE 2005]**
(b) Emf, potential difference, electric potential
(c) heat, work done, energy
(d) Dipole moment, electric flux, electric field

47. Out of the following pairs, which one does not have identical dimensions? **[AIEEE 2005]**

(a) Angular momentum and Planck's constant
(b) Impulse and momentum
(c) Moment of inertia and moment of a force
(d) Work and torque

48. Which one of the following represents the correct dimensions of the coefficient of viscosity? **[AIEEE 2004]**

(a) $[ML^{-1}T^{-2}]$ (b) $[MLT^{-1}]$
(c) $[ML^{-1}T^{-1}]$ (d) $[ML^{-2}T^{-2}]$

49. Dimensions of $\frac{1}{\mu_0 \varepsilon_0}$, where symbols have their usual meaning, are **[AIEEE 2003]**

(a) $[L^{-1}T]$ (b) $[L^2T^2]$
(c) $[L^2T^{-2}]$ (d) $[LT^{-1}]$

50. The physical quantities not having the same dimensions are **[AIEEE 2003]**

(a) torque and work
(b) momentum and Planck's constant
(c) stress and Young's modulus
(d) speed and $(\mu_0\varepsilon_0)^{-1/2}$

Answers

1. (b)	**2.** (a)	**3.** (c)	**4.** (d)	**5.** (d)	**6.** (c)	**7.** (a)	**8.** (a, b, d)	**9.** (d)	**10.** (a)
11. (d)	**12.** (a)	**13.** (d)	**14.** (c)	**15.** (a)	**16.** (b)	**17.** (c)	**18.** (d)	**19.** (c)	**20.** (b)
21. (a)	**22.** (b)	**23.** (a)	**24.** (d)	**25.** (a)	**26.** (b)	**27.** (c)	**28.** (b)	**29.** (b)	**30.** (a)
31. (c)	**32.** (a)	**33.** (b)	**34.** (d)	**35.** (d)	**36.** (a)	**37.** (a)	**38.** (d)	**39.** (a)	**40.** (a)
41. (a)	**42.** (a)	**43.** (c)	**44.** (d)	**45.** (d)	**46.** (a)	**47.** (c)	**48.** (c)	**49.** (c)	**50.** (b)

Hints & Solutions

1. $X = C = [M^{-1}L^{-2}T^2Q^2]$, $Z = [MT^{-1}Q^{-1}]$

$$Y = \frac{X}{Z^2} = \frac{[M^{-1}T^2L^{-2}Q^2]}{[MT^{-1}Q^{-1}]^2} = [M^{-3}T^4L^{-2}Q^4]$$

2. Unit of a = unit of v = m/s = ms^{-1}

and unit of c = unit of $\frac{v}{t^2} = \frac{m/s}{s^2} = m/s^3 = ms^{-3}$

3. A weber is the unit of magnetic flux in SI system.

4. s_t = distance travelled, u = velocity.

So, dimensionally its not a correct equation.

5. Let $L = h^a c^b G^c$

Then $[M^0L^1T^0] = [ML^2T^{-1}]^a[LT^{-1}]^b[M^{-1}L^3T^{-2}]^c$

$= [M]^{a-c}\,[L]^{2a+b+3c}\,[T]^{-a-b-2c}$

Hence, $a - c = 0$, $2a + b + 3c = 1$, $-a - b - 2c = 0$

Solving, these equations, we get

$$a = \frac{1}{2}, b = -\frac{3}{2}, c = \frac{1}{2}$$

$\therefore \quad [L] = [h^{1/2}\cdot c^{-3/2}\cdot G^{1/2}]$

6. Dimensional formula for magnetic permeability μ [or μ_0] is $[MLT^{-2}A^{-2}]$

7. $$\left[\frac{e^2}{4\pi\varepsilon_0 hc}\right] = \frac{[AT]^2}{[M^{-1}L^{-3}T^4A^2]\cdot[ML^2T^{-1}]\cdot[LT^{-1}]} = [M^0L^0T^0]$$

8. $h = [ML^2T^{-1}]$; $c = [LT^{-1}]$

$m_e = [M]$, $G = [M^{-1}L^3T^{-2}]$

$c = AT$; $m_p = M$

$$\frac{\lambda c}{G} = \frac{[ML^2T^{-1}]\,[LT^{-1}]}{[M^{-1}L^3T^{-2}]} = [M^2] \Rightarrow M = \sqrt{\frac{hc}{G}}$$

$$\frac{h}{c} = \frac{[ML^2\ T^{-1}]}{[LT^{-1}]} = [ML]$$

$$L = \frac{\lambda}{cM} = \frac{\lambda}{c}\sqrt{\frac{G}{\lambda c}} = \frac{\sqrt{G\lambda}}{c^{3/2}}$$

From $c = [LT^{-1}]$, $T = \frac{L}{c} = \frac{\sqrt{Gh}}{c^{3/2}c} = \frac{\sqrt{Gh}}{c^{5/2}}$

Hence, out of (a), (b), (d) any one can be taken to express L, M, T in terms of three chosen fundamental quantities.

9. $n_2 = n_1\left[\frac{L_1}{L_2}\right]\left[\frac{T_1}{T_2}\right]^{-2} = 10\left[\frac{\text{metre}}{\text{km}}\right]\left[\frac{\text{sec}}{\text{h}}\right]^{-2}$

$$n_2 = 10\left[\frac{\text{m}}{10^3\text{m}}\right]\left[\frac{\text{sec}}{3600\,\text{sec}}\right]^{-2} = 129600$$

10. $\left[\frac{GIM^2}{E^2}\right] = \frac{[M^{-1}L^3T^{-2}]\times[MLT^{-1}]\times[M]^2}{[ML^2T^{-2}]^2} = [M^0L^0T]$

So, dimensions of $\frac{GIM^2}{E^2}$ are same as that of time.

11. Here, $A = 1.0\,\text{m} \pm 0.2\,\text{m}$

$B = 2.0\,\text{m} \pm 0.2\,\text{m}$

$x = \sqrt{AB} = \sqrt{(1.0)(2.0)} = 1.414\,\text{m}$

Rounding off to two significant digits, $x = \sqrt{AB} = 1.414\,\text{m}$

Now, $\frac{\Delta x}{x} = \frac{1}{2}\left[\frac{\Delta A}{A} + \frac{\Delta B}{B}\right] = \frac{1}{2}\left[\frac{0.2}{1.0} + \frac{0.2}{2.0}\right] = \frac{0.6}{2\times 2.0}$

$$\Delta x = \frac{0.6x}{2\times 2.0} = 0.15\times 1.414$$

$$= 0.2121$$

Rounding off to one significant digit, $\Delta x = 0.2\,\text{m}$

Hence, $\sqrt{AB} = 1.4\,\text{m} \pm 0.2\,\text{m}$

12. Let $v \propto \sigma^a\rho^b\lambda^c$

Equating dimensions on both sides.

$$[M^0L^1T^{-1}] \propto [MT^{-2}]^a[ML^{-3}]^b[L]^c$$
$$\propto [M]^{a+b}[L]^{-3b+c}[T]^{-2a}$$

Equating the powers of M, L, T on both sides, we get

$a + b = 0$ and $-3b + c = 1$

$-2a = -1$

Solving, we get

$$a = \frac{1}{2}, b = -\frac{1}{2}, c = -\frac{1}{2}$$

$\therefore$ $v \propto \sigma^{1/2}\rho^{-1/2}\lambda^{-1/2}$

$\therefore$ $v^2 \propto \frac{\sigma}{\rho\lambda}$

13. Resistance $R = \frac{\text{Potential difference}}{\text{Current}}$

$$= \frac{V}{I} = \frac{W}{qI}$$

($\because$ Potential difference is equal to work done per unit charge)

So, dimensions of R

$$= \frac{[\text{Dimensions of work}]}{[\text{Dimensions of charge}]\ [\text{Dimensions of current}]}$$

$$= \frac{[ML^2T^{-2}]}{[IT]\ [I]}$$

$$= [ML^2T^{-3}I^{-2}]$$

14. Density $\rho = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi r^3}$

$$\frac{d\rho}{\rho}\times 100 = \left(\frac{\Delta M}{M} + \frac{3\Delta r}{r}\right)\times 100$$

$$= \left(\frac{0.1}{12.1} + 3\times\frac{0.1}{10}\right)\times 100$$

$$= 3.83\,\%$$

15. In the given equation, $\frac{\alpha z}{k\theta}$ should be dimensionless

$\therefore$ $[\alpha] = \left[\frac{k\theta}{z}\right] \Rightarrow [\alpha] = \frac{[ML^2T^{-2}K^{-1}\times K]}{[L]} = [MLT^{-2}]$

and $[p] = \left[\frac{\alpha}{\beta}\right] \Rightarrow [\beta] = \left[\frac{\alpha}{p}\right] = \frac{[MLT^{-2}]}{[ML^{-1}T^{-2}]} = [M^0L^2T^0]$

16. $(N+1)$ VSD $= N$ MSD

$\therefore$ $1\,\text{VSD} = \frac{N}{N+1}\,\text{MSD}$

Vernier constant = (1 MSD – 1 VSD) (value of MSD)

$$= \left(1 - \frac{N}{N+1}\right)\times a = \frac{a}{N+1}$$

17. As $A = 3.25 \pm 0.01\,\text{cm}$

and $B = 4.19 \pm 0.01\,\text{cm}$

$\therefore$ $Y = B - A$

$= 4.19 - 3.25 = 0.94\,\text{cm}$

and $\Delta Y = \Delta B + \Delta A$

$= 0.01\,\text{cm} + 0.01\,\text{cm} = 0.02\,\text{cm}$

$\therefore$ $Y = (0.94 \pm 0.02)\,\text{cm}$

18. Absolute error in g is

$$\Delta g = \left(\frac{\Delta L}{L} + \frac{2\Delta T}{T}\right)g = \left(\frac{0.01}{1.21} + \frac{2\times 1}{140}\right)\times 9.8$$

$$= (0.0227\times 9.8)$$

$$= 0.22\,\text{ms}^{-2}$$

19. As $V = \frac{4}{3}\pi r^3$

Hence, $\frac{\Delta V}{V} = 3\frac{\Delta r}{r} = 3\times 1\% = 3\%$

20. $\lambda_m T = b$ or $b^4 = \lambda_m^4 T^4$

and $\frac{\text{energy}}{\text{area}\times\text{time}} = \sigma T^4$

or $\sigma = \frac{\text{energy}}{(\text{area}\times\text{time})T^4}$

$$\sigma b^4 = \left(\frac{\text{energy}}{\text{area}\times\text{time}}\right)\lambda_m^4$$

or $[\sigma b^4] = \frac{[ML^2T^{-2}]}{[L^2][T]}[L^4] = [ML^4T^{-3}]$

21. $\rho = \frac{M}{\frac{4}{3}\pi r^3} = \frac{4.692 \times 3}{4 \times 3.14 \times (10.01)^3 \times 10^{-6}}$

$$\rho = 1.12 \times 10^3 \text{ kg-m}^{-3}$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + \frac{3\Delta r}{r}$$

$$= \left(\frac{0.001}{4.692} + \frac{3 \times 0.01}{10.01}\right) \times 1.12 \times 10^3$$

$$= 3.97 \text{ kg-m}^{-3}$$

22. $p = \frac{a - t^2}{bx}$

$\Rightarrow$ $pbx = a - t^2$

$\Rightarrow$ $[pbx] = [a] = [T^2]$

or $[b] = \frac{[T^2]}{[p][x]} = \frac{[T^2]}{[ML^{-1}T^{-2}][L]} = [M^{-1}T^4]$

$\therefore$ $\left[\frac{a}{b}\right] = \frac{[T^2]}{[M^{-1}T^4]} = [MT^{-2}]$

23. Here, $l = (16.2 \pm 0.1)$ cm ; $b = (10.1 \pm 0.1)$ cm

$$A = l \times b = 16.2 \times 10.1 = 163.62$$

Rounding off to three significant digits

$$A = 164 \text{cm}^2$$

$$\frac{\Delta A}{A} = \left(\frac{\Delta l}{l} + \frac{\Delta b}{b}\right) = \frac{0.1}{16.2} + \frac{0.1}{10.1} = \frac{1.01 + 1.62}{16.2 \times 10.1} = 2.63 \text{ cm}^2$$

Rounding off to one significant figure

$$\Delta A = 3 \text{cm}^2$$

$\therefore$ $A = (164 \pm 3) \text{ cm}^2$

24. $y = a\cos 2\omega t = a(1 - 2\sin^2 \omega t) = a\left(1 - \frac{2x^2}{a^2}\right)$

This is equation of a parabola, hence trajectory is a parabola.

25. We are given $[F] = \frac{X}{\text{Linear density}} + [Y]$

So, the dimensions of Y are the same as that of F, *i.e.*,

$$[Y] = [F] = [MLT^{-2}]$$

Now, $[MLT^{-2}] = \left[\frac{X}{ML^{-1}}\right]$

$\Rightarrow$ $X = [M^2L^0T^{-2}]$

26. The self-inductance L of a coil in which the current varies at a rate $\frac{dI}{dt}$ and is given by $e = -L\frac{dI}{dt}$, where e is the electromotive force (emf) induced in the coil. Now, the dimensions of emf are the same as that of the potential difference, *i.e.*, $[ML^2T^{-3}I^{-1}]$

Now, $L = \frac{-e}{dI/dt}$

Hence, the dimensions of L are

$$[L] = \frac{\text{dimensions of } e}{\text{dimensions of } I \text{ / dimensions of } t}$$

$$= \frac{[ML^2T^{-3}I^{-1}]}{[I/T]} = [ML^2T^{-2}I^{-2}]$$

27. Since, the time period, $T = \frac{1}{2\pi}\sqrt{\frac{l}{g}}$

Thus, for calculating the error, we get

$$\frac{\Delta T}{T} = \pm\left[\frac{1}{2}\frac{\Delta l}{l} + \frac{1}{2}\frac{\Delta g}{g}\right] = \pm\left[\frac{1}{2} \times 2\% + \frac{1}{2} \times 4\%\right] = \pm 3\%$$

28. $1 \text{ MSD} = \frac{1}{10} \text{ cm} = 0.1 \text{ cm}$

10 VSD = 8 MSD

Hence, we get

$$1 \text{ VSD} = \frac{8}{10} \text{ MSD} = \frac{8}{10} \times (0.1) = 0.08 \text{ cm}$$

Thus, the least count = 1 MSD − 1VSD

$$= 0.1 - 0.08 = 0.02 \text{ cm}$$

Here, MSD indicates the main scale divisions and VSD indicates the vernier scale divisions.

30. Work done is $W = Fx\cos\theta$. Since, $\cos\theta$ is dimensionless, the dependence of W on θ cannot be determined by the dimensional method.

31. The degree of accuracy (and hence the number of significant figures) of a measurement cannot be increased by changing the unit.

32. It is true that trigonometrical ratios do not have dimensions. Therefore, method of finding dimensions cannot be utilized for deriving formula involving trigonometrical ratio.

33. $[c] = [LT^{-1}] = 3 \times 10^8 \text{ ms}^{-1}$

and $[g] = [LT^{-2}] = 10 \text{ ms}^{-2}$

So, $\frac{c}{g} = \frac{[LT^{-1}]}{[LT^{-2}]} = T = \frac{3 \times 10^8}{10} = 3 \times 10^7 \text{s}$

$$T = 3 \times 10^7 \text{s}$$

35. The mass of the bee has 2 significant figures in kg, whereas the mass of the flower has three significant figures. Hence, the sum must be rounded off to the third decimal place. Therefore, the correct significant figure is 0.012.

36. $A = \pi r^2 = 3.142 \times (0.021)^2 = 0.00138562 \text{ cm}^2$. Now there are only two significant figure in 0.021 cm. Hence the result must be rounded off to two significant figures as $A = 0.0014 \text{cm}^2$.

37. Average speed $= \frac{100.5 \text{ m}}{10.3 \text{ s}} = 9.708737 \text{ ms}^{-1}$

The distance has four significant figures but the time has only three. Hence the result must be rounded off to three significant figure to 9.71 ms^{-1}.

38. Angular momentum $= r \times P = rP \sin\theta$

$= [\text{LM LT}^{-1}]$

Dimension $= [\text{ML}^2\text{T}^{-1}]$, Latent heat $L = \frac{Q}{M}$

Dimension $[\text{L}^2\text{T}^{-2}]$, Capacitance $C = \frac{Q}{V}$

$= \frac{(IT)^2}{W} \quad \left(\text{as } V = \frac{W}{q}\right)$

$= [\text{A}^2\text{T}^2\text{M}^{-1}\text{L}^{-2}\text{T}^{+2}] = [\text{M}^{-1}\text{L}^{-2}\text{T}^4\text{A}^2]$

39. From Ohm's law,

$R = \frac{V}{i} \Rightarrow \ln R = \ln V - \ln i$

$\Rightarrow \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta i}{i} = 3\% + 3\% = 6\%$

40. Diameter of wire,

$d = \text{MSR} + \text{CSR} \times \text{LC}$

$= 0 + 52 \times \frac{1}{100}$

$= 0.52$ mm

$= 0.052$ cm

41. Number of significant figures in $23.023 \Rightarrow 5$

$0.0003 \Rightarrow 1$

$2.1 \times 10^{-3} \Rightarrow 3$

42. Least count $= \frac{\text{Value of main scale division}}{\text{Number of divisions on vernier scale}}$

$= \frac{1}{30} \text{ MSD} = \frac{1}{30} \times \frac{1^\circ}{2} = \frac{1^\circ}{60} = 1 \text{ min}$

43. $F = qvB$

$B = \frac{F}{qv} = [\text{MC}^{-1}\text{T}^{-1}]$

44. Diameter $= \text{MSR} + \text{CSR} \times \text{LC} + \text{ZE}$

$= 3 + 35 \times (0.5/50) + 0.3$

$= 3.38$ mm

45. In refractive index of glass using a travelling microscope, distance is measured by a screw gauge provided on the microscope.

46. Dipole moment = charge × (distance)

Electric flux = (electric field) × (area)

47. $I = mr^2$

$\therefore \quad [I] = [\text{ML}^2]$

and τ moment of force $= r \times F$

$\therefore \quad [\tau] = [\text{L}][\text{MLT}^{-2}] = [\text{ML}^2\text{T}^{-2}]$

48. By Newton's formula

$\eta = \frac{F}{A(\Delta v_x / \Delta z)}$

$\therefore$ Dimensions of η

$= \frac{\text{Dimensions of force}}{\text{Dimensions of area} \times \text{Dimensions of velocity gradient}}$

$= \frac{[\text{MLT}^{-2}]}{[\text{L}^2][\text{T}^{-1}]}$

$= [\text{ML}^{-1}\text{T}^{-1}]$

49. As we know that formula of velocity is

$v = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$\Rightarrow \quad v^2 = \frac{1}{\mu_0 \varepsilon_0} = [\text{LT}^{-1}]^2$

$\therefore \quad \frac{1}{\mu_0 \varepsilon_0} = [\text{L}^2\text{T}^{-2}]$

50. Planck's constant (in terms of unit)

$(h) = \text{J-s}$

$= [\text{ML}^2\text{T}^{-2}][\text{T}]$

$= [\text{ML}^2\text{T}^{-1}]$

Momentum $(p) = \text{kg-ms}^{-1}$

$= [\text{M}]\,[\text{L}][\text{T}^{-1}]$

$= [\text{MLT}^{-1}]$