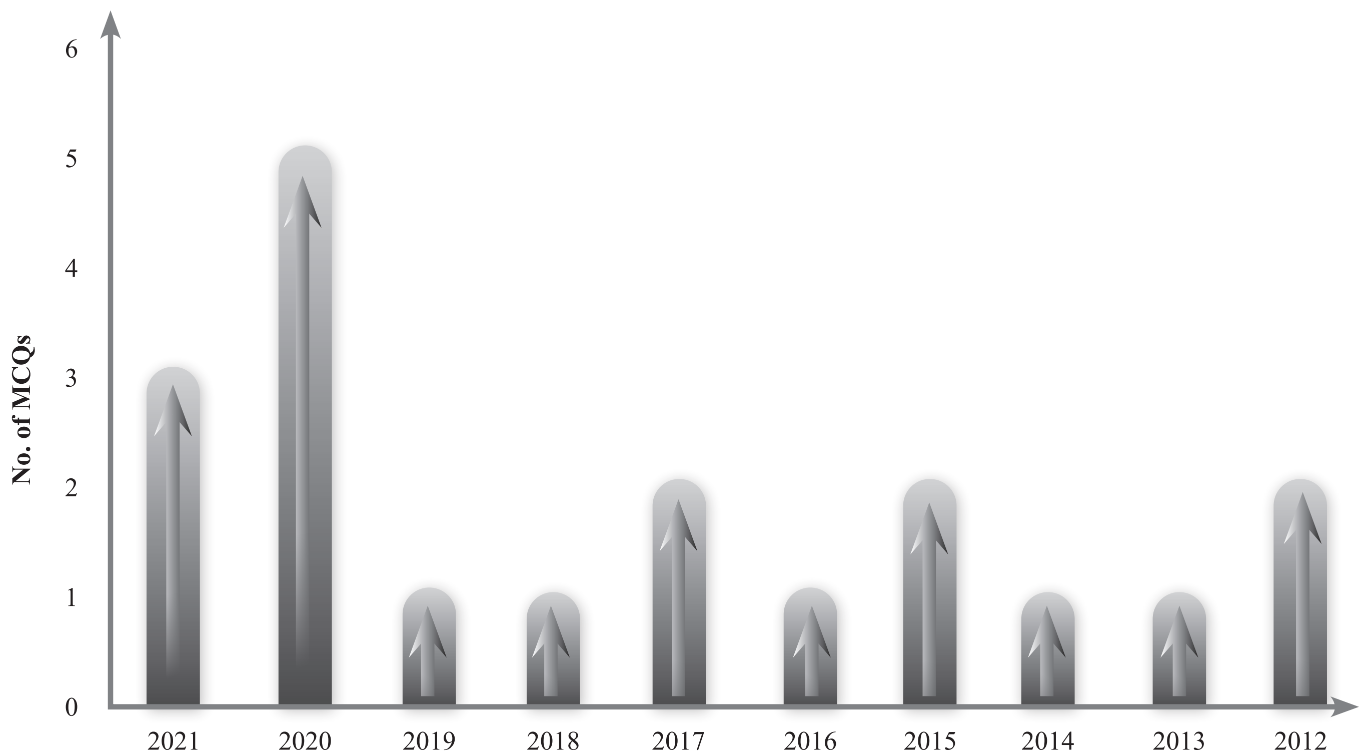
Units and Measurements

Past Years NEET Trend



Investigation Report

TARGET EXAM	PREDICTED NO. OF MCQs	CRITICAL CONCEPTS
NEET	1-2	• SI units, Dimensional Analysis, Errors

Perfect Practice Plan

Topicwise Questions	Learning Plus	Multiconcept MCQs	NEET Past 10 Years Questions	Total MCQs
59	26	11	19	115

PHYSICAL QUANTITIES

All quantities that can be measured are called physical quantities. e.g. length, mass, force, work done, etc. In physics we study about physical quantities and their inter relationship.

There are two types of physical quantities

(*i*) Fundamental quantities
(*ii*) Derived quantities

Fundamental Quantity: Physical quantities which cannot be expressed in terms of any other physical quantities are called fundamental physical quantities.

E.g. length, mass, time, temperature etc.

Derived Quantity: Physical Quantities which are derived from fundamental quantities are called derived quantities.

E.g. Area, density, force etc.

MEASUREMENT

Measurement is the comparison of a physical quantity with a standard of the same physical quantity.
Different countries followed different standards.

Units of Measurement:

A fixed measurement chosen as a standard of measurement to measure a physical quantity is called a Unit.

To measure a physical quantity means to determine the number of times its standard unit is contained in that physical quantity.

A standard Unit is necessary for the sake of

(*i*) Accuracy,
(*ii*) Convenience,
(*iii*) Uniformity and
(*iv*) Equal justice to all.

The standard unit chosen should have the following characteristics.

(*i*) Consistency (or) invariability
(*ii*) Availability (or) reproducibility
(*iii*) Imperishability (Permanency)
(*iv*) Convenience and acceptability.

The numerical value obtained on measuring a physical quantity is inversely proportional to the magnitude of the unit chosen.

$$\boxed{n \,\alpha\, \frac{1}{U}} \Rightarrow \boxed{n_1U_1 = n_2U_2}$$

Where n_1 and n_2 are the numerical values U_1 and U_2 are the units of same physical quantity in different systems.

Fundamental unit: The unit used to measure the fundamental quantity is called fundamental unit.

e.g., Metre for length, kilogram for mass etc.

Derived unit: The unit used to measure the derived quantity is called derived unit.

e.g., m^2 for area, gm cm^{-3} for density etc...

Systems of Units:

There are four systems of units

F.P.S C.G.S
M.K.S SI

FPS or British Engineering system: In this system length, mass and time are taken as fundamental quantities and their base units are foot (ft), pound (lb) and second (s) respectively.

CGS or Gaussian system: In this system the fundamental quantities are length, mass and time and their respective units are centimetre (cm), gram (g) and second (s).

MKS system: In this system also the fundamental quantities are length, mass and time but their fundamental units are metre (m), kilogram (kg) and second (s) respectively.

Units of some fundamental physical quantities in different systems

Type of physical Quantity	Physical Quantity	System		
		CGS	MKS	FPS
Fundamental	Length	cm	m	ft
	Mass	g	kg	lb
	Time	s	s	s

International system (SI) of units: This system is modification over the MKS system. Besides the three base units of MKS system four fundamental and two supplementary units are also included in this system.
Based on SI there are three categories of physical quantities.
7 fundamental quantities
2 supplementary quantities
and derived quantities

SET OF FUNDAMENTAL QUANTITIES

A set of physical quantities which are completely independent of each other and all other physical quantities can be expressed in terms of these physical quantities is called Set of Fundamental Quantities.

Fundamental Quantities and Their S.I. Units

There are seven fundamental quantities and two supplementary quantities in S.I. system. The names and units with symbols are given below:

SI Base Quantities and Their Units

S. No.	Physical quantity	Unit	Symbol
1	Length	Metre	m
2	Mass	Kilogram	kg
3	Time	Second	s
4	Temperature	Kelvin	kg
5	Electric current	Ampere	A
6	Luminous Intensity	Candela	cd
7	Amount of substance	Mole	mol

Supplementary quantities			
1.	Plane angle	Radian	Rad
2.	Solid angle	Steradian	sr

Some Special Units for Length:

angstrom (Å) = 10^{-10} *m* = 10^{-8} cm

nanometre (nm) = 10^{-9} *m* = 10 Å

Fermi = 10^{-15} *m*

Micron = 10^{-6} *m*

X-ray unit = 10^{-13} *m*

1 A.U. = Distance between sun & earth

= 1.496×10^{11} *m*

Light year = 9.46×10^{15} *m*

Par sec = 3.26 light years = 30.84×10^{15} *m*

Bohr radius = 0.5×10^{-10} *m*

Mile = 1.6 km

Some Special Units for Mass:

Quintal = 100 kg

Metric ton = 1000 kg

Atomic mass unit (a.m.u) = 1.67×10^{-27} kg

Some Special Units for Time:

One day = 86400 second
Shake = 10^{-8} second
One light year is distance travelled by light in one year in vacuum or air. This unit is used in astronomy.
Astronomical unit is the mean distance of the earth from the sun. This unit is used in astronomy.

DIMENSIONS AND DIMENSIONAL FORMULA

All the physical quantities of interest can be derived from the base quantities. "The power (exponent) of base quantity that enters into the expression of a physical quantity, is called the dimension of the quantity in that base. To make it clear, consider the physical quantity force.
Force = mass × acceleration

$$\text{mass} \times \frac{\text{length/time}}{\text{time}}$$

= mass × length × $(\text{time})^{-2}$
So the dimensions of force are 1 in mass, 1 in length and –2 in time. Thus
[Force] = MLT^{-2}
Similarly energy has dimensional formula given by
[Energy] = ML^2T^{-2}
i.e. energy has dimensions, 1 in mass, 2 in length and –2 in time.

Such an expression for a physical quantity in terms of base quantities is called dimensional formula.
Physical quantity can be further of four types :

1. Dimension less constant *i.e.* 1,2,3, π etc.
2. Dimension less variable *i.e.* angle θ etc.
3. Dimensional constant *i.e.* *G*, *h* etc.
4. Dimensional variable *i.e.* *F*, *v*, etc.

Dimension

Dimensions of a physical quantity are the powers to which the fundamental units are to be raised to obtain one unit of that quantity

DIMENSIONAL EQUATION

Whenever the dimension of a physical quantity is equated with its dimensional formula, we get a dimensional equation.

Dimensional Formula

An expression showing the powers to which the fundamental units are to be raised to obtain one unit of the derived quantity is called Dimensional formula of that quantity.

In general the dimensional formula of a quantity can be written as $[M^xL^yT^z]$. Here *x*,*y*,*z* are dimensions.

Dimensional Constants

The physical quantities which have dimensions and have a fixed value are called dimensional constants.

Eg: Gravitational Constant (*G*), Planck's Constant (*h*), Universal gas constant (*R*), Velocity of light in vacuum (*c*) etc.,

Dimensionless Quantities

Dimensionless quantities are those which do not have dimensions but have a fixed value.

(*a*) Dimensionless quantities without units.
Eg: Pure numbers, etc.,

(*b*) Dimensionless quantities with units.
Eg: Angular displacement-radian, angle Joule's constant-joule/calorie,etc.,

PRINCIPLE OF HOMOGENEITY

The magnitude of a physical quantity may be added or subtracted from each other only if they have the same dimension, also the dimension on both sides of an equation must be same. This is called as principle of homogeneity.

Dimensional Variables

Dimensional variables are those physical quantities which have dimensions and do not have fixed value.

Eg: velocity, acceleration, force, work, power... etc.

Dimensionless Variables

Dimensionless variables are those physical quantities which do not have dimensions and do not have fixed value.

Eg: Specific gravity, refractive index, Coefficient of friction, Poisson's Ratio etc.,

USES OF DIMENSIONAL ANALYSIS

(i) To check the dimensional correctness of a given physical relation

It is based on principle of homogeneity, which states that a given physical relation is dimensionally correct if the dimensions of the various terms on either side of the relation are the same.

> ✍ **KEY NOTE**
> - Powers are dimensionless
> - sin θ, eq, cos θ, log θ gives dimensionless value and in above expression θ is dimensionless
> - We can add or subtract quantity having same dimensions.

TRAIN YOUR BRAIN

Q. The position of a particle at time t, is given by the equation, $x(t) = \frac{v_0}{\alpha}(1 - e^{-\alpha t})$, where v_0 is a constant and $\alpha > 0$. The dimensions of v_0 & α are respectively.

(*a*) $M^0L^1T^0$ & T^{-1} (*b*) $M^0L^1T^{-1}$ & T

(*c*) $M^0L^1T^{-1}$ & T^{-1} (*c*) $M^1L^1T^{-1}$ & LT^{-2}

Sol. **(*c*)** $[v_0] = [x][\alpha] = M^0L^1T^{-1}$ & $[\alpha][t] = M^0L^0T^0$
$\Rightarrow [\alpha] = M^0L^0T^{-1}$

Q. Check the accuracy of the relation $T = 2\pi\sqrt{\frac{L}{g}}$ for a simple pendulum using dimensional analysis.

Sol. The dimensions of LHS = the dimension of $T = [M^0L^0T^1]$

The dimensions of $RHS = \left(\frac{\text{dim.of length}}{\text{dim.of acc}^n}\right)^{1/2}$

($\because$ 2π is a dimensionless const.)

$$= \left(\frac{L}{LT^{-2}}\right)^{1/2} = (T^2)^{1/2} = (T) = [M^0L^0T^1]$$

(ii) To establish a relation between different physical quantities

If we know the various factors on which a physical quantity depends, then we can find a relation among different factors by using principle of homogeneity.

(iii) To convert units of a physical quantity from one system of units to another

It is based on the fact that,

Numerical value × unit = constant

So on changing unit, numerical value will also get changed. If n_1 and n_2 are the numerical values of a given physical quantity and u_1 and u_2 be the units respectively in two different systems of units, then

$n_1u_1 = n_2u_2$

TRAIN YOUR BRAIN

Q. Convert 1 newton (SI unit of force) into dyne (CGS unit of force)

Sol. The dimensional equation of force is
$[F] = [M^1L^1T^{-2}]$

Therefore if n_1, u_1 and n_2, u_2 corresponds to SI & CGS unit respectively, then

$$n_2u_2 = n_1u_1 \Rightarrow n_2 = n_1\left[\frac{M_1}{M_2}\right]^1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2} = 1$$

$$\left[\frac{kg}{g}\right]\left[\frac{m}{cm}\right]\left[\frac{s}{s}\right]^{-2} = 1\times1000\times100\times1 = 10^5$$

$\Rightarrow 10^5$ Dyne = 1 N

Q. Let us find an expression for the time period t of a simple pendulum. The time period t may possibly depend upon (i) mass m of the bob of the pendulum, (ii) length l of pendulum, (iii) acceleration due to gravity g at the place where the pendulum is suspended.

Sol. Let (i) $t \propto m^a$ (ii) $t \propto \ell^b$ (iii) $t \propto g^c$

Combining all the three factors, we get

$t \propto m^a\ell^bg^c$ or $t = Km^a\ell^bg^c$

Where K is a dimensionless constant of proportionality.

Writing down the dimensions on either side of equation, we get

$$[T] = [M^a][L^b][LT^{-2}]^c = [M^aL^{b+c}T^{-2c}]$$

Comparing dimensions we can get $t = K\sqrt{\frac{\ell}{g}}$

Q. A calorie is a unit of heat or energy and it equals about 4.2 J, where 1 J = 1 kg m^2/s^2. Suppose we employ a system of units in which the unit of mass equals α kg, the unit of length equals β metre, the unit of time is γ second. Show that a calorie has a magnitude $4.2\,\alpha^{-1}\beta^{-2}\gamma^2$ in terms of the new units.

Sol. 1 cal = 4.2 kg m^2s^{-2}

SI	New system
$n_1 = 4.2$	$n_2 = ?$
$M_1 = 1$ kg	$M_2 = \alpha$ kg
$L_1 = 1$ m	$L_2 = \beta$ metre
$T_1 = 1$ s	$T_2 = \gamma$ second

Dimensional formula of energy is $[ML^2T^{-2}]$

Now, $n_2 = n_1\left[\frac{M_1}{M_2}\right]^1\left[\frac{L_1}{L_2}\right]^2\left[\frac{T_1}{T_2}\right]^{-2}$

$$= 4.2\left[\frac{1\,kg}{\alpha\,kg}\right]^1\left[\frac{1\,m}{\beta\,m}\right]^2\left[\frac{1\,s}{\gamma\,s}\right]^{-2} = 4.2\,\alpha^{-1}\beta^{-2}\gamma^2$$

TRAIN YOUR BRAIN

Q. The distance covered by a particle in time t is given by $x = a + bt + ct^2 + dt^3$; find the dimensions of a, b, c and d.

Sol. The equation contains five terms. All of them should have the same dimensions. Since $[x]$ = length, each of the remaining four must have the dimension of length.

Thus, $[a]$ = length = L

$[bt] = L$, or $[b] = LT^{-1}$

$[ct^2] = L$, or $[c] = LT^{-2}$

and $[dt^3] = L$ or $[d] = LT^{-3}$

The Following is the list of some Physical Quantities with their Formula and Dimensional Formula				
S. No.	**Physical Quantity**	**Explanation or Formulae**	**Dimensional Formulae**	**S.I.Unit**
1.	Distance, Displacement, Wave Length, Radius of gyration, Circumference, Perimeter, Light year, Par-sec.		$[M^0 L^1 T^0]$	m
2.	Mass		$[M^1 L^0 T^0]$	kg
3.	Period of oscillation, Time, time constant	$T = \frac{\text{total time}}{\text{No.of oscillations}}$ T = Capacity × Resistance	$[M^0 L^0 T^1]$	s
4.	Frequency	Reciprocal of time period $n = \frac{1}{T}$	$[M^0 L^0 T^{-1}]$	Hertz (Hz)
5.	Area	A = length × breadth	$[M^0 L^2 T^0]$	m^2
6.	Volume	V = Length × breadth × height	$[M^0 L^3 T^0]$	m^3
7.	Density	$D = \frac{\text{Mass}}{\text{Volume}}$	$[M^1 L^{-3} T^0]$	kgm^{-3}
8.	Linear density	$\lambda = \frac{\text{Mass}}{\text{Length}}$	$[M^1 L^{-1} T^0]$	kgm^{-1}
9.	Speed, Velocity	$v = \frac{\text{displacement}}{\text{time}}$	$[M^0 L^1 T^{-1}]$	ms^{-1}
10.	Acceleration	$a = \frac{\text{Change in Velocity}}{\text{time}}$	$[M^0 L^1 T^{-2}]$	ms^{-2}
11.	Linear Momentum	P = mass × velocity	$[M^1 L^1 T^{-1}]$	$kgms^{-1}$
12.	Impulse	J = Force × time	$[M^1 L^1 T^{-1}]$	Ns
13.	Force	F = Mass × acceleration	$[M^1 L^1 T^{-2}]$	N
14.	Work,Energy,PE, KE, Strain Energy	W = Force × displacement P.E = mgh; KE = $\frac{1}{2}MV^2$ $SE = \frac{1}{2}$ × Stress × Strain × Volume	$[M^1 L^2 T^{-2}]$	J(or) N.m
15.	Power	$P = \frac{\text{Work}}{\text{time}}$	$[M^1 L^2 T^{-3}]$	JS^{-1} (or) watt

The Following is the list of some Physical Quantities with their Formula and Dimensional Formula				
S. No.	**Physical Quantity**	**Explanation or Formulae**	**Dimensional Formulae**	**S.I.Unit**
16.	Pressure , Stress, Modulus of Elasticity (Y, n, k)	$\text{pressure} = \frac{\text{Force}}{\text{Area}}$ $Y = \frac{\text{Stress}}{\text{Strain}}$	$[M^1 L^{-1} T^{-2}]$	Nm^{-2} (or) Pascal
17.	Strain	$\frac{\text{Change in dimension}}{\text{Original dimensions}}$	$[M^0 L^0 T^0]$	No units
18.	Strain energy density	$E = \frac{\text{Work}}{\text{Volume}}$	$[M^1 L^{-1} T^{-2}]$	Jm^{-3}
19.	Angular displacement	$\theta = \frac{\text{length of arc}}{\text{radius}}$	$[M^0 L^0 T^0]$	rad
20.	Angular Velocity	$\omega = \frac{\text{angular displacement}}{\text{time}}$	$[M^0 L^0 T^{-1}]$	$rads^{-1}$
21.	Angular acceleration	$\alpha = \frac{\text{Change in angular velocity}}{\text{time}}$	$[M^0 L^0 T^{-2}]$	$rads^{-2}$
22.	Angular momentum	L = Linear momentum × arm	$[M^1 L^2 T^{-1}]$	Js
23.	Planck's constant	$h = \frac{\text{energy}}{\text{frequency}}$	$[M^1 L^2 T^{-1}]$	Js
24.	Torque	$\tau = \text{force} \times \perp dis\tan ce$	$[M^1 L^2 T^{-2}]$	Nm
25.	Acceleration due to gravity(g) = gravitational field strength	$g = \frac{\text{weight}}{\text{mass}}$	$[M^0 L T^{-2}]$	ms^{-2} or Nkg^{-1}
26.	Universal gravitational Constant	$G = \frac{F.d^2}{M_1.M_2}$	$[M^{-1} L^3 T^{-2}]$	$Nm^2 kg^{-2}$
27.	Moment of inertia	$I = MK^2$	$[M^1 L^2 T^0]$	kgm^2
28.	Velocity gradient	$\frac{dv}{dx}$	$[M^0 L^0 T^{-1}]$	S^{-1}
29.	Coefficient of Viscosity	$\eta = \frac{\text{tangential stress}}{\text{Velocity gradient}}$	$[M^1 L^{-1} T^{-1}]$	Pa s (or) Ns m^{-2}
30.	Heat energy	$ms\theta$	$[M^1 L^2 T^{-2}]$	Joule
31.	Temperature	θ	$[M^0 L^0 T^0 . \theta^1]$	Kelvin (K)
32.	Specific heat Capacity	$S(\text{or})C = \frac{\text{heat energy}}{\text{mass} \times \text{temp.}}$	$[M^0 L^2 T^{-2} . \theta^{-1}]$	$JKg^{-1} K^{-1}$
33.	Water Equivalent	$W = MC$	$[M^1 L^0 T^0]$	kg
34.	Coefficient of Thermal expansion	α or β or γ ask	$[\theta^{-1}]$	k^{-1}
35.	Universal gas constant	$R = \frac{PV}{nT}$	$[M^1 L^2 T^{-2} \theta^{-1} mol^{-1}]$	$Jmol^{-1} K^{-1}$

The Following is the list of some Physical Quantities with their Formula and Dimensional Formula				
S. No.	**Physical Quantity**	**Explanation or Formulae**	**Dimensional Formulae**	**S.I.Unit**
36.	Gas constant (for 1 gram)	$r = \frac{R}{Mol.wt}$	$[M^0\ L^2\ T^{-2}\ \theta^{-1}\ mol^{-1}]$	$Jkg^{-1}\ K^{-1}$
37.	Boltzman constant (for 1 Molecule)	$k = \frac{R}{\text{AvagadroNo.}}$	$[M^1\ L^2\ T^{-2}\ \theta^{-1}]$	JK^{-1} molecule^{-1}
38.	Mechanical equivalent of heat	$J = \frac{W}{H}$	$[M^0\ L^0\ T^0]$	no S.I. units
39.	Coeff of Thermal Conductivity	$K = \frac{Q.d}{A\ \Delta\theta.t}$	$[M^1\ L^1\ T^{-3}\ \theta^{-1}]$	$Js^{-1}\ m^{-1}\ K^{-1}$ (or) $Wm^{-1}\ K^{-1}$
40.	Entropy	$\frac{dQ}{T} = \frac{\text{heat energy}}{\text{temperature}}$	$[M^1\ L^2\ T^{-2}\ \theta^{-1}]$	JK^{-1}
41.	Stefan's Constant	$\sigma = \frac{\Delta E}{\Delta A.\Delta T.\theta^4}$	$[M^1\ L^0\ T^{-3}\ \theta^{-4}]$	$Js^{-1}\ m^{-2}\ K^{-4}$ (or) $Wm^{-2}\ K^{-4}$
42.	Thermal resistance	$R = \frac{d\theta}{\left(\frac{dQ}{dt}\right)} = \frac{\text{temp} \times \text{time}}{\text{Heat}}$ or $R = \frac{d}{K.A}$	$[M^{-1}\ L^{-2}\ T^3\ \theta^1]$	KsJ^{-1}
43.	Temperature gradient	$\frac{\text{Change in temp}}{\text{length}} = \frac{d\theta}{dl}$	$[\theta\ L^{-1}]$	Km^{-1}
44.	Pressure gradient	$\frac{\text{Change in pressure}}{\text{length}} = \frac{dp}{dl}$	$[M^1\ L^{-2}\ T^{-2}]$	Pascal m^{-1}
45.	Enthalpy	Heat. (ΔQ)	$[M^1\ L^2\ T^{-2}]$	Joule
46.	Magnetic Moment	$M = 2l \times m$ = pole strength × length of magnet	$[M^0\ L^2\ T^0\ A]$	Am^2
47.	Magnetic flux	$\phi = \overline{B} \times \overline{A}$ = (Magnetic induction × area)	$[M^1\ L^2\ T^{-2}\ A^{-1}]$	Wb
48.	Magnetic induction field strength	$\overline{B} = \frac{\phi}{A} = \frac{\text{Magnetic flux}}{\text{area}} = \frac{F}{il}$	$[M^1\ L^0\ T^{-2}\ A^{-1}]$	Tesla (or) Wbm^{-2} (or) $Na^{-1}\ m^{-1}$
49.	Magnetic permeability of free space	$\mu_0 = \frac{4\pi.Fd^2}{m_1.m_2}$	$[M^1\ L^1\ T^{-2}\ A^{-2}]$	Hm^{-1}
50.	Electric current	I	$[M^0\ L^0\ T^0\ A\cdot]$	A
51.	Charge	Q = Current × time	$[M^0\ L^0\ T\ .A]$	C
52.	Electric dipole moment	P = Charge × distance	$[M^0\ L^0\ T\ .A]$	Cm
53.	Electric field strength (or) Electric field Intensity	$E = \frac{\text{force}}{\text{Charge}}$	$[M^1\ L\ T^{-3}\ A^{-1}]$	NC^{-1}
54.	Electrical flux (ϕ_E)	Electrical Intensity × area	$[M^1\ L^3\ T^{-3}\ A^{-1}]$	Nm^2C^{-1}

The Following is the list of some Physical Quantities with their Formula and Dimensional Formula				
S. No.	**Physical Quantity**	**Explanation or Formulae**	**Dimensional Formulae**	**S.I.Unit**
55.	Electric potential (or) Potential difference	$V = \frac{\text{Work}}{\text{Charge}}$	$[M^1 L^2 T^{-3} A^{-1}]$	V
56.	Electrical resistance	$R = \frac{\text{Pot.diff}}{\text{Current}}$	$[M^1 L^2 T^{-3} A^{-2}]$	Ω
57.	Electrical conductance	$C = \frac{1}{R} = \frac{1}{\text{Resistance}}$	$[M^{-1} L^{-2} T^3 A^2]$	mho (or) siemen (S)
58.	Specific resistances (or) Resistivity ρ (or)	$\rho = \frac{R.A}{l}$	$[M^1 L^3 T^{-3} A^{-2}]$	Ohm m
59.	Electrical conductivity Current density (Current per unit area of cross section)	$s = \frac{1}{\text{Resistivity}}$ J = Electrical Intensity × Conductivity or $\left(\frac{\text{Current}}{\text{area}}\right)$	$[M^{-1} L^{-3} T^3 A^2]$ $[M^0 L^{-2} T^0 A]$	Ohm^{-1} m^{-1} (or) siemen m^{-1} 70 Am^{-2}
60.	Capacitance	$C = \frac{Q}{V} = \frac{\text{Charge}}{\text{Potential}}$	$[M^{-1} L^{-2} T^4 A^2]$	F
61.	Self (or) Mutual Inductance	$L = \frac{dE}{\left(\frac{dI}{dt}\right)} = \frac{\text{Voltage} \times \text{time}}{\text{Current}}$	$[M^1 L^2 T^{-2} A^{-2}]$	H (or) Wb/amp
62.	Electrical permittivity of free space	$\varepsilon_0 = \frac{q_1.q_2}{4\pi F d^2}$	$[M^{-1} L^{-3} T^4 A^2]$	farad/m
63.	Surface charge density	$\frac{\text{Charge}}{\text{area}}$	$[M^0 L^{-2} T^1 A^1]$	Cm^{-2}
64.	Focal Power	$P = \frac{1}{\text{focal length}}$	$[M^0 L^{-1} T^0]$	Dioptre

Physical Quantities Having Same Dimensional Formulas:

Distance, Displacement, radius, light year wavelength, radius of gyration $[L]$

Speed, Velocity, Velocity of light $[LT^{-1}]$

Acceleration, acceleration due to gravity, intensity of gravitational field, centripetal acceleration $[LT^{-2}]$

Impulse, Change in momentum $[MLT^{-1}]$

Force, Weight, Tension, Thrust $[MLT^{-2}]$

Work, Energy, Moment of force or Torque, Moment of couple $[ML^2T^{-2}]$

Force constant, Surface Tension, Spring constant, Energy per unit area $[MT^{-2}]$

Angular momentum, Angular impulse, Planck's constant $[ML^2T^{-1}]$

Angular velocity, Frequency, Velocity gradient, Decay constant, rate of disintegration $[T^{-1}]$

Stress, Pressure, Modulus of Elasticity, Energy density $[ML^{-1}T^{-2}]$

Specific heat, Specific gas constant $[L^2T^{-1}\theta^{-1}]$

Thermal capacity, Entropy, Boltzmann constant, Molar thermal capacity, $[ML^2T^{-2}\theta^{-1}]$

Intensity of magnetic field, Intensity of magnetization $[IL^{-1}]$

Frequency, angular frequency, angular velocity, Disintegration constant and velocity gradient have same dimensional formula $[M^0L^0T^{-1}]$

Pressure, stress, coefficient of elasticity, energy density have same dimensional formula $[ML^{-1}T^{-2}]$

Electric field and potential gradient have same dimensional formula $[MLT^{-3}A^{-1}]$

Surface tension, surface energy, force gradient and spring constant have same dimensional formula $[ML^0T^{-2}]$

Force, weight and Energy gradient have same dimensions $[MLT^{-2}]$

Light year, wave length and radius of gyration have same dimensional formula $[M^0LT^0]$

Strain, Poisson's ratio, refractive index, dielectric constant, coefficient of friction, relative permeability, Magnetic susceptibility, Electric susceptibility, angle, solid angle, Trigonometric ratios, exponential constant are all dimensionless.

TRAIN YOUR BRAIN

Q. If P is the pressure of a gas and ρ is its density, then find the dimension of velocity

(*a*) $P^{1/2}\rho^{-1/2}$ (*b*) $P^{1/2}\rho^{1/2}$

(*c*) $P^{-1/2}\rho^{1/2}$ (*d*) $P^{-1/2}\rho^{-1/2}$

Sol. (***a***) **Method - I**

$[P] = [ML^{-1}T^{-2}]$ ...(1)

$[\rho] = [ML^{-3}]$ ...(2)

Dividing eq. (1) by (2)

$[P\rho^{-1}] = [L^2T^{-2}]$

$\Rightarrow [LT^{-1}] = [P^{1/2}\rho^{-1/2}]$ $\Rightarrow [V] = [P^{1/2}\rho^{-1/2}]$

Method - II

$V \propto P^a \rho^b$

$V = kP^a \rho^b$

$[LT^{-1}] = [ML^{-1}T^{-2}]^a [ML^{-3}]^b$

$a = \frac{1}{2}, b = -\frac{1}{2} \quad \Rightarrow [V] = [P^{1/2}\rho^{-1/2}]$

LIMITATIONS OF DIMENSIONAL ANALYSIS METHOD:

- Dimensionless quantities cannot be determined by this method.
- Constant of proportionality cannot be determined by this method.
- This method is not applicable to trigonometric, logarthmic and exponential functions.
- In the case of physical quantities which are dependent upon more than three physical quantities, this method will be difficult.
- In some cases, the constant of proportionality also possesses dimensions. In such cases we cannot use this system.
- If one side of equation contains addition or subtraction of physical quantities, we cannot use this method.

We use certain special length units for short and large lengths. These are

Unit	Definition and Conversion
1 fermi	$1f = 10^{-15}$ m
1 angstrom	$1Å = 10^{-10}$ m
1 astronomical unit	1 AU = (average distance of the sum from the earth) $= 1.496 \times 10^{11}$ m
1 light year	1 1y = 9.46×10^{15} m (Distance that light travels with velocity of 3×10^8m/ s) in 1 year
1 par sec	3.08×10^6 m Parsec is the distance at which average radius of earth's orbit subtends an angle of 1 arc second

Accuracy and Precision

The numerical values obtained on measuring physical quantities depend upon the measuring instruments, methods of measurement.

A unit of measurement of a physical quantity is the standard reference of the same physical quantity which is used for comparison of the given physical quantity.

Accuracy refers to how closely a measured value agrees with the true values.

Precision refers to what limit or resolution the given physical quantity can be measured

Accuracy refers to the closeness of observed values to its true value of the quantity while precision refer's to closeness between the different observed values of the same quantity. High precision does not mean high accuracy. The difference between accuracy and precision can be understand by the following example: Suppose three students are asked to find the length of a rod whose length is known to be 2.250cm. The observations are given in the table.

Student	Measurement-1	Measurement-2	Measurement-3	Average length
A	2.25cm	2.27cm	2.26cm	2.26cm
B	2.252cm	2.250cm	2.251cm	2.251cm
C	2.250cm	2.250cm	2.251cm	2.250cm

It is clear from the above table, that the observation taken by a student A are neither precise nor accurate. The observations of student B are more precise. The observations of student C are precise as will as accurate

Types of Errors

Uncertainity in measurement of a physical quantity is called the error in measurement.

The difference between the measured value and true value as per standard method without mistakes is called the error.

Error = True value - Measured value Correction = – error

True value means, standard value free of mistakes.

Errors are broadly classified into 3 types:

(*i*) Systematic errors
(*ii*) Random errors
(*iii*) Gross errors

(i) Systematic Errors/Controllable Errors

The errors due to a definite cause and which follow a particular rule are called systematic errors. They always occur in one direction. Following are some systematic errors

Constant Error

Systematic errors with a constant magnitude are called constant errors.

The constant arised due to imperfect design, zero error in the instrument or any other such defects. These are also called instrumental errors.

Zero Error:

The error due to improper designing and construction.

Ex: If a screw gauge has a zero error of -4 head scale divisions, then every reading will be 0.004cm less than the true value.

Environmental Error:

The error arised due to external conditions like changes in environment, changes in temperature, pressure, humidity etc.

Ex: Due to rise in temperature, a scale gets expanded and this results in error in measuring length.

Imperfection in Experimental Technique or Procedure:

The error due to experimental arrangement, procedure followed and experimental technique is called Imperfection error.

Ex: In calorimetric experiments, the loss of heat due to radiation, the effect on weighing due to buoyancy of air cannot be avoided.

Personal Errors or Observational Errors:

These errors are entirely due to personal pecularities like individual bias, lack of proper settings of the aparatus, carelessness in taking observations.

$$\text{Probable error} \propto \frac{1}{\text{no. of readings}}$$

Ex: Parallax error

(ii) Random Errors

They are due to uncontrolled disturbances which influence the physical quantity and the instrument. These errors are estimated by statistical methods

$$\text{Random error} \propto \frac{1}{\text{no. of observations}}$$

Ex: The errors due to line voltage changes and backlash error.

Backlash errors are due to screw and nut.

(iii) Gross Errors

The cause for gross errors are improper recording, neglecting the sources of the error, reading the instrument incorrectly, sheer carelessness

Ex: In a tangent galvanometer experiment, the coil is to be placed exactly in the magnetic meridian and care should be taken to see that no other magnetic material are present in the vicinity.

No correction can be applied to these gross errors.

When the errors are minimized, the accuracy increases.

The systematic errors can be estimated and observations can be corrected.

Random errors are compensating type. A physical quantity is measured number of times and these values lie on either side of mean value-with random errors. These errors are estimated by statistical methods and accuracy is achieved.

> ✍ **KEY NOTE**
>
> - Personal errors like parallax error can be avoided by taking proper care.
> - The instrumental errors are avoided by calibrating the instrument with a standard value and by applying proper corrections.

True value and Errors

True Value

In the measurement of a physical quantity the arithmetic mean of all readings which is found to be very close to the most accurate reading is to be taken as True value of the quantities. If a_1, a_2, a_3 .... a_n are readings then true value

$$a_{\text{mean}} = \frac{1}{n}\sum_{i=1}^{n} a_i$$

Absolute Errors

The magnitude of the difference between the true value of the measured physical quantity and the value of individual measurement is called absolute error.

|True value - measured values|

$$\Delta a_{\text{i}} = |a_{\text{mean}} - a_i|$$

The absolute error is always positive.

Mean Absolute Error

The arithmetic mean of all the absolute errors is considered as the mean absolute error or final absolute error of the value of the physical concerned.

$$\Delta a_{\text{mean}} = \frac{|\Delta a_1| + |\Delta a_2| + --- |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{\infty} |\Delta a_i|$$

The mean absolute error is always positive.

Relative Error

The relative error of a measured physical quantity is the ratio of the mean absolute error to the mean value of the quantity measured.

Relative error $= \frac{\Delta a_{\text{mean}}}{a_{\text{mean}}}$

It is a pure number having no units.

Percentage Error

$$\delta a = \left[\frac{\Delta a_{\text{mean}}}{a_{\text{mean}}} \times 100\right]\%$$

> ✍ **KEY NOTE**
>
> Relative error and percentage error give a measure of accuracy i.e., percentage error increases accuracy decreases

Combination of Errors

- **Error due to addition**

  If $Z = A + B$

  $\Delta Z = \Delta A + \Delta B$ (Max. Possible error)

  $Z \pm \Delta Z = (A \pm \Delta A) + (B \pm \Delta B)$

  Relative error $= \frac{\Delta A + \Delta B}{A + B}$

  Percentage error $= \frac{\Delta A + \Delta B}{A + B} \times 100$

- **Error due to subtraction**

  If $Z = A - B$

  $\Delta Z = \Delta A + \Delta B$ (Max. Possible error)

  $Z \pm \Delta Z = (A \pm \Delta A) - (B \pm \Delta B)$

  Relative error $= \frac{\Delta A + \Delta B}{A - B}$

  Percentage error $= \frac{\Delta A + \Delta B}{A - B} \times 100$

- Whether it is addition or subtraction, absolute error is same.

  More admissible error $\Delta U = \pm\sqrt{(\Delta x)^2 + (\Delta y)^2}$

- In subtraction the percentage error increases.
- **Error due to Multiplication**

  If $Z = AB$ then $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

  $\frac{\Delta Z}{Z}$ is called fractional error or relative error.

  Percentage error $= \frac{\Delta Z}{Z} \times 100$

  $= \left(\frac{\Delta A}{A} \times 100\right) + \left(\frac{\Delta B}{B} \times 100\right)$

- Here Percentage error is the sum of individual percentage errors.
- **Error due to Division:**

  $Z = \frac{A}{B}$

  Maximum possible relative error

  $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

  Max. Percentage error in division $\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$

- **Error due to Power**

  If $Z = A^n$

  $\frac{\Delta Z}{Z} = n\frac{\Delta A}{A}$

- In more general form

  If $Z = \frac{A^p B^q}{C^r}$ then maximum fractional error in Z is

  $\frac{\Delta Z}{Z} = p\frac{\Delta A}{A} + q\frac{\Delta B}{B} + r\frac{\Delta C}{C}$

  As we check for maximum error a + ve sign is to be taken for the term $r\frac{\Delta C}{C}$

  Maximum Percentage error in

  $Z = \frac{\Delta Z}{Z} \times 100 = p\frac{\Delta A}{A} \times 100 + q\frac{\Delta B}{B} \times 100 + r\frac{\Delta C}{C} \times 100$

TRAIN YOUR BRAIN

Q. In an experiment, two capacities measured are (1.3 ± 0.1) μF and (2.4 ± 0.2) μF. Calculate the total capacity if the two capacitors are connected in parallel with percentage error

Sol. Here, C_1 = (1.3 ± 0.1) μF and C_2 = (2.4 ± 0.2) μF.

In parallel, $C_p = C_1 + C_2$ = 1.3 + 2.4 = 3.7 μF

$\Delta C_p = \pm(\Delta C_1 + \Delta C_2)$ = ± (0.1 + 0.2) = ± 0.3 % error $= \pm\frac{0.3}{3.7} \times 100 = \pm 8.1\%$

Hence, C_p = (3.7 ± 0.3) μF = 3.7 μF ± 8.1%

Significant Figures:

A significant figure is defined as the figure, which is considered reasonably, trust worthy in number.

Eg: π = 3.141592654

(upto 10 digits)

= 3.14 (with 3 figures)

= 3.1416 (upto 5 digits)

> ✍ **KEY NOTE**
> The significant figures indicate the extent to which the readings are reliable.

Rules for Determining the Number of Significant Figures:

- All the non-zero digits in a given number are significant without any regard to the location of the decimal point if any.
  Ex: 194,52 has five significant digits.
  1945.2 or 194.52 all have the same number of significant digits,that is 5.
- All zeros accruing between two non zero digits are significant without any regard to the location of decimal point if any.
  Ex: 107008 has six significant digits.
  107.008 or 1.07008 has also got six significant digits.
- If the number is less than one, all the zeros to the right of the decimal point but to the first non-zero digit are not significant.
  Ex: 0.000408
  In this example all zeros before 3 are non-significant.
  (*i*) All zeros to the right of a decimal point are significant if they are not followed by a non-zero digit.
  Ex: 40.00 has 4 significant digits
  (*ii*) All zeros to the right of the last non-zero digit after the decimal point are significant.
  Ex: 0.05700 has 4 significant digits
- All zeros to the right of the last non-zero digit in a number having no decimal point are not significant.
  Ex: 4030 has 3 significant digits

Rounding off Numbers

The process of omitting the non significant digits and retaining only the desired number of significant digits, incorporating the required modifications to the last significant digit is called rounding off the number.

Rules for Rounding off Numbers:

- The preceding digit is raised by 1 if the immediate insignificant digit to the dropped is more than 5.
  Ex: 4727 is rounded off to three significant figures as 4730.
- The preceding digit is to be left unchanged if the immediate insignificant digit to be dropped is less than 5.
  Ex: 4722 is rounded off to three significant figures as 4720
- If the immediate insignificant digit to be dropped is 5 then there will be two different cases
  (*a*) If the preceding digit is even, it is to be unchanged and 5 is dropped.
  Ex: 4.7252 is to be rounded off to two decimal places. The digit to be dropped here is 5 (along with 3) and the preceding digit 2 is even and hence to be retained as two only
  4.7252 = 4.72
  (*b*) If the preceding digit is odd, it is to be raised by 1
  Ex: 4.7153 is to be rounded off to two decimal places. As the preceding digit 1 is odd, it is to be raised by 1 as 2.
  4.7153 = 4.72

Rules for Arithmetic Operations with Significant Figures:

In multiplication or division, the final result should retain only that many significant figures as are there in the original number with the least number of significant figures.

Ex: But the result should be limited to the least number of significant digits-that is two digits only. So final answer is 9.9.

In addition or subtraction the final result should retain only that many decimal places as are there in the number with the least decimal places.

Ex: 2.2 + 4.08 + 3.12 + 6.38 = 15.78. Finally we should have only one decimal place and hence 15.78 is to be rounded off as 15.8.

VERNIER CALIPERS

It is a device used for accurate measurement. There are two scales in the vernier calipers, vernier scale and main scale. The main scale is fixed whereas the vernier scale is movable along the main scale.

Determination of Least Count (Vernier Constant)

Note the value of the main scale division and count the number n of vernier scale divisions. Slide the movable jaw till the zero of vernier scale coincides with any of the mark of the main scale and find the number of divisions (n – 1) on the main scale coinciding with n divisions of vernier scale. Then

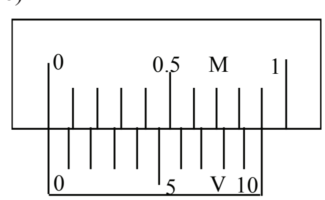
$$\text{nV.S.D.} = (n-1)\text{ M.S.D. or } 1\text{ V.S.D.} = \text{M.S.D.}\left(\frac{n-1}{n}\right)$$

$$\text{or V.C.} = 1\text{ M.S.D.} - 1\text{ V.S.D.} = \left(1-\frac{n-1}{n}\right)\text{M.S.D} = \frac{1}{n}\text{M.S.D}$$

Determination of Zero error and Zero Correction

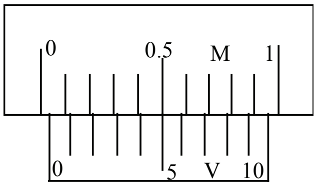
For this purpose, movable jaw B is brought in contact with fixed jaw A.
One of the following situations will arise.

(*i*) Zero of Vernier scale coincides with zero of main scale (see figure)



In this case, zero error and zero correction, both are nil.
Actual length = observed (measured) length.

(*ii*) Zero of vernier scale lies on the right of zero of main scale (see figure)



Here 5^{th} vernier scale division is coinciding with any main sale division.

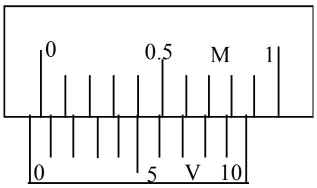
Hence, N = 0, n = 5, L.C. = 0.01 cm.

Zero error N = n × (L.C.) = 0 + 5 × 0.01 = + 0.05 cm

Zero correction = – 0.05 cm.

Actual length will be 0.05 cm less than the observed (measured) length.

(*iii*) zero of the vernier scale lies left of the main scale.



Here, 5^{th} vernier scale division is coinciding with any main scale division.

In this case, zero of vernier scale lies on the right of –0.1 cm reading on main scale.

Hence, N = – 0.1 cm, n = 5, L.C. = 0.01 cm

Zero error = N + n × (L.C.) = – 0.1 + 5 × 0.01 = –0.05 cm.

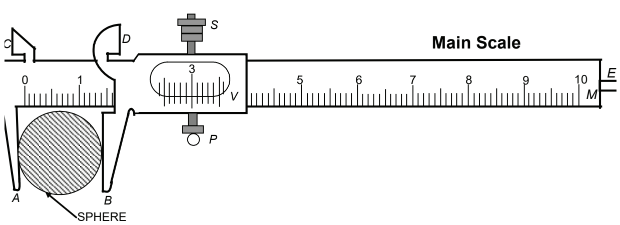
Zero correction = +0.05 cm.

Actual length will be 0.05 cm more than the observed (measured) length.

Experiment

Aim: To measure the diameter of a small spherical/cylindrical body, using a vernier caliper.

Apparatus: Vernier caliper, a spherical (pendulum bob) or a cylinder.



Theory: If with the body between the jaws, the zero of vernier scale lies ahead of Nth division of main scale, then main scale reading (M.S.R.) = N.

If n^{th} division of vernier scale coincides with any division of main scale, then vernier scale reading (V.S.R.)

= n × (L.C.) (L.C. is least count of vernier caliper)

= n × (V.C.) (V.C. is vernier constant of vernier caliper)

Total reading, T.R. = M.S.R. + V.S.R. = N + n × (V.C.)

TRAIN YOUR BRAIN

Q. The least count of vernier caliper is 0.1 mm. The main scale reading before the zero of the vernier scale is 10 and the zeroth division of the vernier scale coincides with the main scale division. Given that each main scale division is 1 mm, what is the measured value?

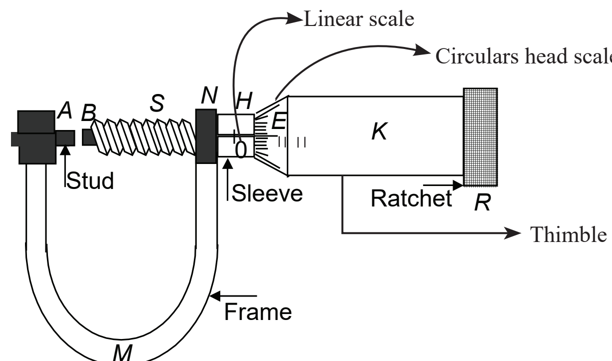
Sol. Length measured with vernier caliper

= reading before the zero of vernier scale + number of vernier divisions coinciding

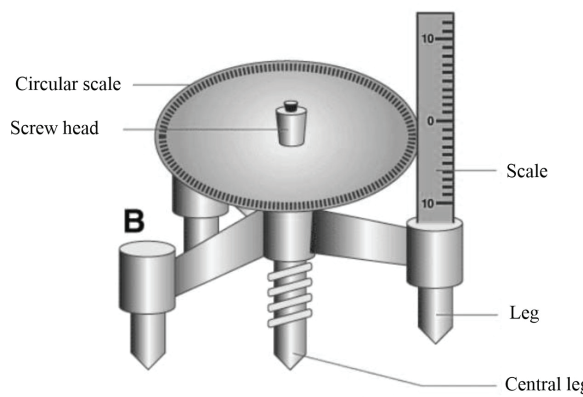
with any main scale division × least count

= 10 mm + 0 × 0.1 mm = 10 mm = 1.00 cm

SCREW GAUGE, SPHEROMETER



Screw gauge



Spherometer

Determination of Least Count of Screw Gauge or Sphero-meter

Note the value of linear (pitch) scale division. Rotate screw to bring zero mark on circular (head) scale on reference line. Note linear scale reading i.e. number of divisions of linear scale uncovered by the cap.

Now give the screw a few known number of rotations. (one rotation completed when zero of circular scale again arrives on the reference line). Again note the linear scale reading. Find difference of two readings on linear scale to find distance moved by the screw.

Then, pitch of the screw

$= \dfrac{\text{Distance moved by in n rotation}}{\text{No. of full rotation (n)}}$

Now count the total number of divisions on circular (head) scale.

Then, least count

$= \dfrac{\text{Pitch}}{\text{Total number of divisions on the circular scale}}$

The least count is generally 0.001 cm.

TRAIN YOUR BRAIN

Q. A vernier caliper has its main scale of 10 cm equally divided into 200 equal parts. Its vernier scale of 25 divisions coincides with 12 mm on the main scale. The least count of the instrument is–

(*a*) 0.020 cm (*b*) 0.002 cm

(*c*) 0.010 cm (*d*) 0.001 cm

Sol. (***b***) In vernier caliper main scale 10 cm.

10 cm divided in 200 divisions. 1 div. $= \dfrac{10}{200}$

$= 0.05$ cm.

12 mm on main scale $= \dfrac{12\,\text{mm}}{0.0.5\,\text{cm}} = 24\,\text{MSD}$

25 V = 24S.

$S - V = S - \dfrac{24}{25}S = \dfrac{1}{25}S$

$\because$ 1S = 0.05 cm

Least count = 0.002 cm

Q. One centimetre on the main scale of vernier caliper is divided into ten equal parts. If 10 divisions of vernier scale coincide with 8 small divisions of the main scale, the least count of the caliper is –

(*a*) 0.005 cm

(*b*) 0.05 cm

(*c*) 0.02 cm

(*d*) 0.01 cm

Sol. (*c*) 1 main scale div = 0.1 cm

10V = 8S

$V = \dfrac{8}{10}S$

$S - V = S - \dfrac{8}{10}S = \dfrac{2}{10}S. = \dfrac{1}{5}S$

But 1S = 0.1 cm

$= \dfrac{0.1}{5} = 0.02$ cm

Least count = 0.02 cm

Q. In four complete revolutions of the cap, the distance travelled on the pitch scale is 2mm. If there are fifty divisions on the circular scale, then

(*a*) Calculate the pitch of the screw gauge

(*b*) Calculate the least count of the screw gauge

Sol. Pitch of screw = Linear distance travelled in one Revolution

$P = \dfrac{2\text{mm}}{4} = 0.5 \text{ mm} = 0.05 \text{ cm}$

Least count

$= \dfrac{\text{Pitch}}{\text{no. of divisions in circular scale}}$

$= \dfrac{0.05}{50} = 0.001$ cm

Q. The pitch of a screw gauge 0.5 mm and there are 50 divisions on the circular scale. In measuring the thickness of a metal plate, there are five divisions on the pitch scale (or main scale) and thirty fourth division coincides with the reference line. Calculate the thickness of the metal plate.

Sol. Pitch of screw = 0.5 mm.

$L.C = \dfrac{0.5}{50} = 0.01$ mm.

Thickness = (5 × 0.5 + 34 × 0.01) mm

= (2.5 + 0.34) = 2.84 mm

ILLUSTRATIONS

1. A new system of units is proposed in which, unit of mass is α kg, unit of length is β m and unit of time is γ s. What will be value of 5 J in this new system?

(*a*) $5\alpha\beta^2\gamma^{-2}$

(*b*) $5\alpha^{-1}\beta^{-2}\gamma^2$

(*c*) $5\alpha^{-2}\beta^{-1}\gamma^{-2}$

(*d*) $5\alpha^{-1}\beta^2\gamma^2$

Sol. (***b***) Joule is a unit of energy.

$n_1 = 5$ $n_2 = ?$

$M_1 = 1$ kg $M_2 = \alpha$ kg

$L_1 = 1$ m $L_2 = \beta$ m

$T_1 = 1$ s $T_2 = \gamma$ s

Dimensional formula of energy is $[ML^2T^{-2}]$. Comparing with $[M^aL^bT^c]$, we get

$a = 1, b = 2, c = -2$

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

$= 5\left(\frac{1\,kg}{\alpha\,kg}\right)^1\left(\frac{1\,m}{\beta\,m}\right)^2\left(\frac{1\,s}{\gamma\,s}\right)^{-2} = \frac{5\gamma^2}{\alpha\beta^2} = 5\alpha^{-1}\beta^{-2}\gamma^2$

2. Given that $y = A\sin\left[\left(\frac{2\pi}{\lambda}(ct - x)\right)\right]$ where y and x are measured in meter. Which of the following statements are true?

(*a*) The unit of λ is same as that of x and A

(*b*) The unit of λ is same as of x but not of A

(*c*) The unit of c is same as that of $\frac{2\pi}{\lambda}$

(*d*) The unit of (ct – x) is same as that of $\frac{2\pi}{\lambda}$

Sol. (*a*) $f = A\sin\left[\left(\frac{2\pi}{\lambda}\right)\right][ct - x]$. Since Angle has [M°L°T°] dimensions. ∴ $\left[\frac{2\pi}{\lambda}(ct - x)\right]$ needs to be dimensionless

$\therefore \frac{c}{\lambda}t = \left[M^oL^oT^o\right], \lambda = ct = \left[M^oL^1T^o\right]$

$x = \lambda = \left[M^0L^1T^0\right]$, A = $[M^0\,L^1\,T^0]$

3. If the unit of force and length are doubled, the unit of energy will be:

(*a*) 1/4 times the original (*b*) 1/2 times the original

(*c*) 2 times the original (*d*) 4 times the original

Sol. (*d*) Work = Energy = F'. L' = 2 F × 2 L, 4 times the original

4. The speed of light c, gravitational constant G and Planck's constant h are taken as fundamental units in a system. The dimensions of time in this new system should be:

(*a*) $[G^{1/2}h^{1/2}c^{-5/2}]$ (*b*) $[G^{-1/2}h^{1/2}c^{-1/2}]$

(*c*) $[G^{-1/2}h^{1/2}c^{-3/2}]$ (*d*) $[G^{-1/2}h^{1/2}c^{1/2}]$

Sol. (*a*) $c = [M^0\,L^1\,T^{-1}]$, $G = [M^{-1}\,L^3\,T^{-2}]$, $h = [M^1\,L^2\,T^{-1}]$

$T = c^a\,G^b\,h^c$

$[T^1] = [M^0\,L^1\,T^{-1}]^a\,[M^{-1}\,L^3\,T^{-2}]^b\,[M^1\,L^2\,T^{-1}]^c$

$[T^1] = M^{-b+c}\;L^{a+3b+2c}\;T^{-a-2b-c}$ ∴ b = c

a + 3b + 2c = 0, a + 2b + c = –1

Solving the three equations

a = –5/2, b = $\frac{1}{2}$, c = 1/2

$T = [c^{-5/2}\,G^{1/2}\,h^{1/2}]$

5. By what percentage should the pressure of a given mass of gas be increased so as the decrease in its volume is 10% at a constant temperature?

(*a*) 5% (*b*) 7.2%

(*c*) 12.5% (*d*) 11.1%

Sol. (*d*) PV = constant

$P'\left(V - \frac{10V}{100}\right) = PV$

$P'\left(\frac{100V - 10V}{100}\right) = PV$

$P'\left(\frac{90V}{100}\right) = PV \rightarrow P' = \frac{10}{9}P$

Percentage increase in volume

$= \frac{(P' - P)}{P}\times 100\%$

$= \left(\frac{10}{9}P - P\right)\times 100\%$

$P = 11.1\%$

6. Percentage error in the measurement of mass and speed are 2% and 3% respectively. The error in the estimation of kinetic energy obtained by measuring mass and speed will be:

(*a*) 12% (*b*) 10%

(*c*) 2% (*d*) 8%

Sol. (*d*) $K = \frac{1}{2}mV^2$

$\frac{\Delta K}{K} = \frac{\Delta m}{m} + \frac{2\Delta V}{V}$

$\frac{\Delta K}{K} = 2 + 3\times 2$

$\frac{\Delta K}{K} = 8\%$

7. If E, m, *l* and G denote energy, mass, angular momentum and gravitational constant respectively, the quantity $\left(\frac{El^2}{m^5G^2}\right)$ has the dimensions of:

(*a*) Mass

(*b*) Length

(*c*) Time

(*d*) Angle

Sol. (*d*) $\left(\frac{El^2}{m^5G^2}\right)=\frac{[M^1L^2T^{-2}][ML^2T^{-1}]^2}{[M^5][M^{-2}L^6T^{-4}]}$

$$=\frac{[M^3L^6T^{-4}]}{[M^3L^6T^{-4}]}=[M^0L^0T^0]$$

Mass = $[M^1]$ Length = $[L^1]$

Time = $[T^1]$

(Angle dimension less)

8. In an experiment four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated as follows: $P=\frac{a^3b^2}{cd}$ % error in P is:

(*a*) 4% (*b*) 14%

(*c*) 10% (*d*) 7%

Sol. (*b*) $P=\frac{a^3b^2}{cd}\Rightarrow\frac{\Delta P}{P}=\pm\left(3\frac{\Delta a}{a}+2\frac{\Delta b}{b}+\frac{\Delta c}{c}+\frac{\Delta d}{d}\right)$

$$=\pm(3\times1+2\times2+3+4)\Rightarrow\pm14\%$$

9. The respective number of significant figure for the number 23.023, 0.0003 and 2.1×10^{-3} are:

(*a*) 5, 1, 2 (*b*) 5, 1, 5

(*c*) 5, 5, 2 (*d*) 4, 4, 2

Sol. (*a*) 23.023 → 5, 0.0003 = 1, 2.1×10^{-3} = 2

10. The dimensions of coefficient of viscosity and self inductance are:

(*a*) $[M L^{-1} T^{-1}]$, $[M L^2 T^{-2} I^{-2}]$

(*b*) $[M^2 L^{-1} T^{-1}]$, $[M L^2 T^{-1} I^{-2}]$

(*c*) $[M L^{-1} T^{-1}]$, $[M L^3 T^{-1} I^{-2}]$

(*d*) $[M^1 L^1 T^{-2}]$, $[M^1 L^3 T^2 I^{-3}]$

Sol. (*a*) $\eta=\frac{F}{A(\Delta V/\Delta L)}=\frac{\text{dimensions of force}}{\text{D. of area}\times\text{D. of velocity gradient}}$

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

$$L=\frac{\text{dimensions of e}}{\text{D. of I / dimension of t}}=\frac{[ML^2T^{-3}I^{-1}]}{[I/T]}$$

$$L=[M L^2 T^{-2} I^{-2}]$$

11. $S_t=U+\frac{1}{2}a(2t-1)$ is:

(*a*) Only numerically correct

(*b*) Only dimensionally correct

(*c*) Both numerically and dimensionally correct

(*d*) Neither numerically nor dimensionally correct

Sol. (*d*) S_t = distance traveled, U = velocity so, it is not dimensionally correct.

12. What are dimensions of E/B?

(*a*) $[LT^{-1}]$ (*b*) $[LT^{-2}]$

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

Sol. (*a*) $\frac{E}{B}=\frac{MLT^{-3}A^{-1}}{MT^{-2}A^{-1}}\ \frac{E}{B}=LT^{-1}$

2nd solutions

Ratio E/B is the speed of EM wave.

∴ Dimension of E/B is the dimension of speed.

13. A physical quantity is given by $X=[M^aL^bT^c]$. The percentage error in measurements of M, L and T are α, β, γ. Then, the maximum % error in the quantity X is:

(*a*) $a\alpha+b\beta+c\gamma$ (*b*) $a\alpha+b\beta-c\gamma$

(*c*) $\frac{a}{\alpha}+\frac{b}{\beta}+\frac{c}{\gamma}$ (*d*) None of these

Sol. (*a*) $X=M^aL^bT^c$

$$\frac{dX}{X}=a\frac{dM}{M}+b\frac{dL}{L}+c\frac{dT}{T}$$

$$\frac{dX}{X}=a\alpha+b\beta+c\gamma$$

14. In dimension of critical velocity, of liquid flowing through a tube are expressed as $\nu_c\propto[\eta^x\rho^y r^z]$ where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by:

(*a*) 1, 1, 1 (*b*) 1, –1, –1

(*c*) –1, –1, 1 (*d*) –1, –1, –1

Sol. (*b*) $\nu_c\propto[\eta^x\rho^y r^z]$

$$[L^1T^{-1}]\propto[M^1L^{-1}T^{-1}]^x[M^1L^{-3}]^y[L^1]^z$$

$$[L^1T^{-1}]\propto[M^{x+y}][L^{-x-3y+z}][T^{-x}]$$

Taking comparison on both size

$x+y=0$, $-x-3y+z=1$, $-x=-1$

$x=1$, $y=-1$, $z=-1$

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

(*a*) 3.59 kg m^{-3} (*b*) 4.692 kg m^{-3}

(*c*) 0 (*d*) 1.12 kg m^{-3}

Sol. (*a*) $\rho f=\frac{m}{\frac{4}{3}\pi r^3}=\frac{4.692\times3}{4\times3.14\times(10.01)^3\times10^{-6}}$

$\rho=1.12\times10^3$ kg /m^3

abs. errors:

Δm = 1gm = 0.001 kg

ΔR = 0.01 cm

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

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

$= 3.59\ kg/m^3$

16. The dimension of Planck's constant equals to that of:

(*a*) Energy (*b*) Momentum
(*c*) Angular momentum (*d*) Power

Sol. (*c*) Dimensions of Planck's constant, $h = \frac{\text{Energy}}{\text{Frequency}}$

$$= \frac{\left[ML^2T^{-2}\right]}{\left[T^{-1}\right]}$$

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

Dimensions of angular momentum L

= Moment of inertia I × Angular velocity

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

17. In the following dimensionally constant equations, we have $F = \frac{X}{\text{Linear density}} + Y$ where F = force. The dimensional formula of X are Y are:

(*a*) $[M\ L\ T^{-2}]$, $[M^2\ L^0\ T^{-2}]$

(*b*) $[M^2\ L^0\ T^{-2}]$, $[M\ L\ T^{-2}]$

(*c*) $[M\ L^2\ T^{-4}]$, $[M^2\ L^{-2}\ T^{-2}]$

(*d*) None of these

Sol. (*b*) $[F] = \left[\frac{X}{L.D}\right] + [Y]$

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

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

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

(*a*) $[ML^2T^{-2}]$

(*b*) $[ML^2T^{-1}I^{-1}]$

(*c*) $[ML^2T^{-3}I^{-2}]$

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

Sol. (*c*) According to Ohm's law,

$V = RI$ or $R = \frac{V}{I}$

Dimensions of $V = \frac{W}{q} = \frac{\left[ML^2T^{-2}\right]}{[IT]}$

$$\therefore [R] = \frac{\left[ML^2T^{-2}/IT\right]}{[I]} = \left[ML^2T^{-3}I^{-2}\right]$$

19. If $A = (1.0\ m \pm 0.2)$ gm and $B = (2.0 \pm 0.2)$ m, then $\sqrt{AB}$ is:

(*a*) 1.4 m ± 0.4 m

(*b*) 1.41 m ± 0.15 m

(*c*) 1.4 m ± 0.3 m

(*d*) 1.4 m ± 0.2 m

Sol. (*d*) $x = \sqrt{AB} = \sqrt{1.0\times 2.0} = 1.414$ m

Rounding off x = 1.4 m

$$\frac{\Delta x}{x} = \frac{1}{2}\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) = \frac{1}{2}\left(\frac{0.2}{1.0} + \frac{0.2}{2.0}\right)$$

= 0.2 m (round figure)

$\sqrt{AB} = (1.4 \pm 0.2)\,m$

Topicwise Questions

DIMENSIONS & DIMENSIONAL FORMULA

1. The dimensions of magnetic moment are:
(*a*) L^2A^{-1} (*b*) L^2A^1
(*c*) LA^2 (*d*) L^2A^{-3}

2. The velocity "V" of a particle is given in terms of time t as $V = at + \frac{b}{t+C}$.
The dimensions of a, b, C are:
(*a*) L^2 ; ML ; T^{-2} (*b*) LT^2 ; LT ; L
(*c*) LT^{-2} ; L ; T (*d*) L ; LT ; T^2

3. Which of the following pairs of physical quantities does not have same dimensional formula?
(*a*) Work and torque
(*b*) Angular momentum and Planck's constant
(*c*) Tension and surface tension
(d) Impulse and linear momentum

4. The equation of a wave is given by:
$$y = A\sin\omega\left(\frac{x}{v} - k\right)$$
where ω is the angular velocity and v is the linear velocity. The dimension of k is:
(*a*) LT (*b*) T
(*c*) T^{-1} (*d*) T^2

5. A unitless quantity:
(*a*) May have a non-zero dimension
(b) Always has a non-zero dimension
(*c*) Never has a non-zero dimension
(*d*) Does not exist

6. Young's modulus of steel is 1.9×10^{11} N/m^2. When expressed in CGS units of dyne/cm^2, it will be equal. to (1 N = 10^5 dyne, 1 m^2 = 10^4 cm^2)
(*a*) 1.9×10^{10} (*b*) 1.9×10^{11}
(*c*) 1.9×10^{12} (*d*) 1.9×10^{13}

7. A dimensionless quantity:
(*a*) May have a unit (*b*) Never has a unit
(*c*) Always has a unit (*d*) Doesn't exist

8. The position x of a particle at time "t" is given by-
$$x = \frac{v_0}{a}\left(1 - e^{-at}\right)$$
Where v_0 is a constant and a > 0.
The dimensions of v_0 and a are:
(*a*) $M^0 L T^{-1}$ and T^{-1} (*b*) $M^0 L T^0$ and T^{-1}
(*c*) $M^0 L T^{-1}$ and LT^{-2} (*d*) $M^0 L T^{-1}$ and T

9. Surface tension has the same dimensions as that of:
(*a*) Coefficient of viscosity (*b*) Impulse
(*c*) Momentum (*d*) Spring constant

10. The dimensions of RC, where R is resistance and C is capacitance are same as that of:
(*a*) Inverse time (*b*) Time
(*c*) Square of time (*d*) Square root of time

11. Dimensions of gravitational constant are:
(*a*) $M^{-1}L^3T^{-2}$ (*b*) $M^{-2}L^3T^{-1}$
(*c*) $M^3L^{-1}T^{-2}$ (*d*) $M^{-1}L^2T^{-3}$

12. The dimensional formula of magnetic flux is:
(*a*) $M^1L^2T^{-2}A^{-1}$ (*b*) $M^1L^0T^{-2}A^{-2}$
(*c*) $M^0L^{-2}T^{-2}A^{-2}$ (*d*) $M^1L^2T^{-1}A^3$

13. Photon is quantum of radiation with energy E = hv, where v is frequency and h is Planck's constant. The dimensions of h are the same as that of:
(*a*) Linear impulse (*b*) Angular impulse
(*c*) Linear momentum (*d*) Angular velocity

14. The pair having the same dimensions are:
(*a*) Angular momentum, work
(*b*) Work, torque
(*c*) Potential energy, linear momentum
(*d*) Kinetic energy, velocity

15. $[ML^3T^{-1}Q^{-2}]$ is dimensions of:
(*a*) Resistivity (*b*) Conductivity
(*c*) Resistance (*d*) None of these

16. If R and L represents respectively resistance and self inductance, which of the following combinations has the dimensions of frequency?
(*a*) $\frac{R}{L}$ (*b*) $\frac{L}{R}$
(*c*) $\sqrt{\frac{R}{L}}$ (*d*) $\sqrt{\frac{L}{R}}$

17. The dimensions of emf in MKS system of unit is:
(*a*) $ML^{-1}T^{-2}Q^{-2}$ (*b*) $ML^2T^{-2}Q^{-2}$
(*c*) $MLT^{-2}Q^{-1}$ (*d*) $ML^2T^{-2}Q^{-1}$

18. The physical quantities not having same dimensions are:
(*a*) Speed and $(\mu_0\varepsilon_0)^{-1/2}$
(*b*) Torque and work
(*c*) Momentum and Planck's constant
(*d*) Stress and Young's modulus

19. The dimensions of physical quantity X in the equation force = $\dfrac{X}{\sqrt{\text{Density}}}$ is given by:

(*a*) $M^1L^4T^{-2}$ (*b*) $M^2L^{-2}T^{-1}$

(*c*) $M^{3/2}L^{-1/2}T^{-2}$ (*d*) $M^1L^{-2}T^{-1}$

20. The dimension of $\dfrac{1}{\sqrt{\varepsilon_0\mu_0}}$ is that of:

(*a*) Velocity (*b*) Time

(*c*) Capacitance (*d*) Distance

21. Given that V is speed, r is the radius and g is the acceleration due to gravity. Which of the following is dimensionless?

(*a*) V^2/rg (*b*) V^2r/g

(*c*) V^2g/r (*d*) V^2rg

22. Which of the following is not a unit of time?

(*a*) Second (*b*) Minute

(*c*) Year (*d*) Light year

23. The dimensions formula for latent heat is:

(*a*) $[M^0L^2T^{-2}]$ (*b*) $[MLT^{-2}]$

(*c*) $[ML^2T^{-2}]$ (*d*) $[ML^2T^{-1}]$

24. If $V = \sqrt{\dfrac{\gamma P}{\rho}}$, then dimensions of γ are:

(*a*) $[M^0L^0T^0]$ (*b*) $[M^0L^0T^{-1}]$

(*c*) $[M^1L^0T^0]$ (*d*) $[M^0L^1T^0]$

25. In the relation:

$y = a \sin(\omega t - kx)$,

the dimensional formula for k is:

(*a*) $[M^0LT]$ (*b*) $[M^0L^{-1}T^0]$

(*c*) $[M^0LT^{-1}]$ (*d*) $[M^0L^{-1}T^{-1}]$

26. Suppose refractive index μ is given as:

$$\mu = A + \frac{\beta}{\lambda^2}$$

Where A and B are constants and λ is the wavelength, then dimensions of B are same as that of:

(*a*) Wavelength (*b*) Volume

(*c*) Pressure (*d*) Area

27. The modulus of elasticity is dimensionally equivalent to:

(*a*) Strain (*b*) Force

(*c*) Stress (*d*) Coefficient of viscosity

28. In the relation: $\dfrac{dy}{dt} = 2\omega\sin(\omega t + \phi_0)$, , the dimensional formula for $(\omega t + \phi_0)$ is:

(*a*) [MLT] (*b*) $[MLT^0]$

(*c*) $[ML^0T^0]$ (*d*) $[M^0L^0T^0]$

29. Dimensions of Stefan's constant are:

(*a*) $[M L^2 T^{-2}]$ (*b*) $[ML^2 T^{-2} \theta^{-4}]$

(*c*) $[M T^{-3} \theta^{-4}]$ (*d*) $[M L^0 T^{-2}]$

30. With usual notation, amongst the following, the one which does not represent the dimensions of time is:

(*a*) $\left[\dfrac{L}{R}\right]$ (*b*) [RC]

(*c*) $\left[\sqrt{LC}\right]$ (*d*) $\left[\dfrac{1}{\sqrt{LC}}\right]$

31. The dimensions of "K" in equation $W = \dfrac{1}{2}Kx^2$ is:

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

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

32. $\dfrac{h}{2\pi}$ is the dimension of:

(*a*) Velocity (*b*) Momentum

(*c*) Energy (*d*) Angular momentum

APPLICATIONS OF DIMENSIONAL ANALYSIS

33. In a particular system, the unit of length, mass and time are chosen to be 10cm, 10g and 0.1 sec respectively. The unit of force in this system will be equivalent to:

(*a*) 0.1N (*b*) 1N

(*c*) 10N (*d*) 100N

34. If momentum (p), area (A) and time (T) are taken to be fundamental quantities, then energy has the dimensional formula:

(*a*) $pA^{-1}T^1$ (*b*) p^2AT

(*c*) $pA^{-1/2}T$ (*d*) $pA^{1/2}T^{-1}$

35. If units of length, mass and force are chosen as fundamental units, the dimensions of time would be:

(*a*) $M^{1/2} L^{-1/2} F^{1/2}$ (*b*) $M^{1/2} L^{1/2} F^{1/2}$

(*c*) $M^{1/2} L^{1/2} F^{-1/2}$ (*d*) $M^1 L^{-1/2} F^{-1/2}$

36. If speed of light (c), acceleration due to gravity (g) and pressure (P) are taken as fundamental units, the dimensions of gravitational constant (G) are:

(*a*) $c^0 g P^{-3}$ (*b*) $c^2 g^3 P^{-2}$

(*c*) $c^0 g^2 P^{-1}$ (*d*) $c^2 g^2 P^{-2}$

37. If energy (E), velocity (V) and force (F) be taken as fundamental quantity, then what are the dimensions of mass:

(*a*) EV^2 (*b*) EV^{-2}

(*c*) FV^{-1} (*d*) FV^{-2}

38. If area (A), velocity (V) and density (ρ) are taken as fundamental units, what is the dimensional formula for force?

(*a*) $[AV^2\rho]$ (*b*) $[A^2V\rho]$

(*c*) $[AV\rho^2]$ (*d*) $[AV\rho]$

39. A student writes the escape velocity as:

$$V_e = \sqrt{\frac{GM}{R^2}}$$

The equation is:

(*a*) Dimensionally incorrect (*b*) Dimensionally correct

(*c*) Numerically correct (*d*) Both (*a*) and (*c*)

ERRORS & MEASUREMENT, SIGNIFICANT FIGURES

40. The number of significant figures in 0.06900 is:

(*a*) 5 (*b*) 4

(*c*) 2 (*d*) 3

41. If the length of rod A is 3.25 ± 0.01cm and that of rod B is 4.19 ± 0.01cm, 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*) 0.94 ± 0.005 cm

42. The sum of the numbers 436.32, 227.2 and 0.301 in appropriate significant figures is:

(*a*) 663.821 (*b*) 664

(*c*) 663.8 (*d*) 663.82

43. A physical quantity A is related to four observations a, b, c and d as follows, $A = \frac{a^2b^3}{c\sqrt{d}}$. The percentage errors of measurement in a, b, c and d are 1%, 3%, 2% and 2% respectively. What is the percentage error in the measurement of quantity A?

(*a*) 12% (*b*) 7%

(*c*) 5% (*d*) 14%

44. The numbers 2.745 and 2.735 on rounding off to 3 significant figures will give:

(*a*) 2.75 and 2.74 (*b*) 2.74 and 2.73

(*c*) 2.75 and 2.73 (*d*) 2.74 and 2.74

45. Error in the measurement of radius of a sphere is 1%. The error in the calculated value of its volume is:

(*a*) 1% (*b*) 3%

(*c*) 5% (*d*) 7%

46. Measure of two quantities along with the precision of respective measuring instrument is:

$A = 2.5\ ms^{-1} \pm 0.5\ ms^{-1}$, $B = 0.10\ s \pm 0.01\ s$. The value of AB will be:

(*a*) (0.25 ± 0.08) m (*b*) (0.25 ± 0.5) m

(*c*) (0.25 ± 0.05) m (*d*) (0.25 ± 0.135) m

47. A wire has a mass (0.3 ± 0.003) g, radius (0.5 ± 0.005) mm and length (6 ± 0.06) cm. The maximum percentage error in the measurement of density is:

(*a*) 1 (*b*) 2

(*c*) 3 (*d*) 4

48. The values of two resistors are $R_1 = (6 \pm 0.3)\ K\Omega$ and $R_2 = (10 \pm 0.2) K\Omega$. The percentage error in the equivalent resistance when they are connected in parallel is:

(*a*) 5.125% (*b*) 2%

(*c*) 3.125% (*d*) 10.125%

49. Which of the following measurement is most precise?

(a) 5.00 mm (*b*) 5.00 cm

(c) 5.00 m (*d*) 5.00 km

50. If $x = a^n$, then fractional error $\frac{\Delta x}{x}$ is equal to:

(*a*) $\pm\left(\frac{\Delta a}{a}\right)^n$ (*b*) $\pm n\left(\frac{\Delta a}{a}\right)$

(*c*) $\pm n \log e \frac{\Delta a}{a}$ (*d*) $\pm n \log \frac{\Delta a}{a}$

51. If voltage V = (100 ± 5)V and current I = (10 ± 0.2) A, the percentage error in resistance R is:

(*a*) 5.2% (*b*) 25%

(*c*) 7% (*d*) 10%

52. The mean length of an object is 5 cm. Which of the following measurements is most accurate?

(*a*) 4.9 cm (*b*) 4.805 cm

(*c*) 5.25 cm (*d*) 5.4 cm

MEASURING INSTRUMENTS

53. In an experiment, it is required to measure the distance between two points which are between 0.7 m to 0.8 m apart. Which of the following instruments should be used so that the distance can be measured to within an accuracy of 0.001 m?

(*a*) A metre rule and a pair of vernier calipers

(*b*) A half-metre rule

(*c*) A metre rule

(*d*) A ten-metre measuring tape

54. In a vernier calipers, one main scale division is x cm and n division of the vernier scale coincide with (n-1) divisions of the main scale. The least count (in cm) of the calipers is:

(*a*) $\left(\frac{n-1}{n}\right)x$ (*b*) $\left(\frac{nx}{n-1}\right)$

(*c*) $\frac{x}{n}$ (*d*) $\left(\frac{x}{n-1}\right)$

55. A student measure the diameter of a thick wire using a screw gauge of least count 0.001 cm. The main scale reading is 2 mm and zero of circular scale division coincides with 50 division above the reference level. If the screw gauge has a zero error of 0.002 cm, the correct diameter of the thick wire is:

(*a*) 0.248 (*b*) 0.428

(*c*) 0.521 (*d*) 0.224

56. In a vernier caliper, ten smallest divisions of the vernier scale are equal to nine smallest division on the main scale. If the smallest division on the main scale is half millimeter, then the vernier constant is–

(*a*) 0.5 mm (*b*) 0.1 mm
(*c*) 0.05 mm (*d*) 0.005 mm

57. A vernier caliper having 1 main scale division = 0.1 cm is designed to have a least count of 0.02 cm. If n be the number of divisions on vernier scale and m be the length of vernier scale, then

(*a*) n = 10, m = 0.5 cm (*b*) n = 9, m = 0.4 cm
(*c*) n = 10, m = 0.8 cm (*d*) n = 10, m = 0.2 cm

58. The pitch of a screw gauge is 0.5 mm and there are 100 divisions on it circular scale. The instrument reads +2 divisions when nothing is put in-between its jaws. In measuring the diameter of a wire, there are 8 divisions on the main scale and 83rd division coincides with the reference line. Then the diameter of the wire is

(*a*) 4.05 mm (*d*) 4.405 mm
(*c*) 3.05 mm (*d*) 1.25 mm

59. The pitch of a screw gauge having 50 divisions on its circular scale is 1 mm. When the two jaws of the screw gauge are in contact with each other, the zero of the circular scale lies 6 division below the line of graduation. When a wire is placed between the jaws, 3 linear scale divisions are clearly visible while 31st division on the circular scale coincide with the reference line. The diameter of the wire is :

(*a*) 3.62 mm (*b*) 3.50 mm
(*c*) 3.5 mm (*d*) 3.74 mm

Learning Plus

1. The time dependence of a physical quantity P is given by $P = P_0 \exp(-\alpha t^2)$, where α is a constant and t is time. The constant α is:

(*a*) Dimensionless (*b*) Has dimensions T^{-2}
(*c*) Has dimension of P (*d*) Has dimensions T^2

2. Which of the following sets cannot enter into the list of fundamental quantities in any system of units?

(*a*) Length, time and velocity
(*b*) Length, mass and velocity
(*c*) Mass, time and velocity
(d) Length, time and mass

3. Dimensions of 'ohm' are same as (where h is planck's constant and e is charge):

(*a*) $\frac{h}{e}$ (*b*) $\frac{h}{e^2}$
(*c*) $\frac{h^2}{e}$ (*d*) $\frac{h^2}{e^2}$

4. The quantity $X = \frac{\varepsilon_0 LV}{t}$; ε_0 is the permitivity of free space, L is length, V is potential difference and t is time. The dimensions of X are same as that of:

(*a*) Resistance (*b*) Charge
(*c*) Voltage (*d*) Current

5. If force (F), length (l) and Current (I) and time (T) are taken as bases then the dimensions of ε_0 are:

(*a*) $[FL^2 I^2 T^{-2}]$ (*b*) $[F^{-1} L^2 I^2 T^2]$
(*c*) $[F^{-1}L^{-2}T^2I^2]$ (*d*) $[F^2L^2T^2I^2]$

6. If Planck's constant (h) and speed of light in vaccum (c) are taken as two fundamental quantities, which one of the following should not, in addition, be taken to express length, mass and time in terms of the three chosen fundamental quantities?

(i) Mass of electron (m_e)
(ii) Universal gravitational constant (G)
(iii) Charge of electron (e)
(iv) Mass of proton (m_p)

(*a*) (i), (ii), (iii) (*b*) (i), (ii), (iv)
(*c*) (i), and (iii) (*d*) only (i)

7. The SI unit of energy is $J = kg\ m^2\ s^{-2}$ that of speed v is ms^{-1} and of acceleration a is ms^{-2}. Which of the formula for kinetic energy (K) given below can you rule out on the basic of dimensional arguments (m stands for the mass of the body).

I. $K = m^2v^2$ **II.** $K = (1/2)\ mv^2$
III. $K = ma$ **IV.** $K = (3/16)\ mv^2$
V. $K = \left(\frac{1}{2}\right)mv^2 + ma$

(*a*) I and II (*b*) Only II
(*c*) II and IV (*d*) I, III and V

8. A physical quantity P is given by $P = \frac{A^3 b^{1/2}}{C^{-4} D^{3/2}}$. The quantity which brings in the maximum percentage error in P is:

(*a*) A (*b*) B
(*c*) C (*d*) D

9. A body travels uniformly a distance of (13.8 ± 0.2)m in a time (4.0 ± 0.3)sec. The velocity of the body within error limits is:

(*a*) (3.45 ± 0.2)m/sec (*b*) (3.45 ± 0.3)m/sec

(*c*) (3.45 ± 0.4)m/sec (*d*) (3.45 ± 0.5)m/sec

10. If $Q = \frac{X^n}{Y^m}$ and Δx is absolute error in the measurement of X, Δy is absolute error in the measurement of Y, then absolute error ΔQ in Q is:

(*a*) $\Delta Q = \pm\left(n\frac{\Delta x}{x} + m\frac{\Delta y}{y}\right)$

(*b*) $\Delta Q = \pm\left(n\frac{\Delta x}{x} + m\frac{\Delta y}{y}\right)Q$

(*c*) $\Delta Q = \pm\left(n\frac{\Delta x}{x} - m\frac{\Delta y}{y}\right)Q$

(*d*) $\Delta Q = \pm\left(\frac{n\Delta x}{x} - \frac{m\Delta y}{y}\right)Q$

11. The length of a rod is (11.05 ± 0.05)cm. What is the length of two rods?

(*a*) (22.1 ± 0.05) cm (*b*) (22.1 ± 0.2) cm

(*c*) (22.10 ± 0.05) cm (*d*) (22.10 ± 0.10) cm

12. A uniform wire of length L, diameter D and density ρ is stretched under a tension T. The correct relation between its fundamental frequency f, the length L and the diameter D is:

(*a*) $f \propto \frac{1}{LD}$ (*b*) $f \propto \frac{1}{L\sqrt{D}}$

(*c*) $f \propto \frac{1}{D^2}$ (*d*) $f \propto \frac{1}{LD^2}$

13. 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

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

(*a*) $[M^0L^0T^0]$ (*b*) $[ML^0T^0]$

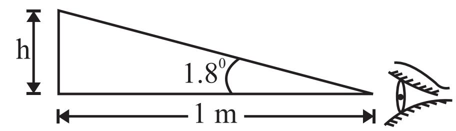
(*c*) $[M^0LT^0]$ (*d*) $[M^0L^0T]$

15. A gas bubble formed from an explosion under water oscillates with a period T proportional to $p^a d^b E^c$, where p is pressure, d is the density of water and E is the total energy of explosion. The values of a, b and c are

(*a*) a = 1, b = 1, c = 2 (*b*) a = 1, b = 2, c = 1

(*c*) $a = \frac{5}{6}, b = \frac{1}{2}, c = \frac{1}{3}$ (*d*) $a = -\frac{5}{6}, b = \frac{1}{2}, c = \frac{1}{3}$

16. A normal human eye can see an object making an angle of 1.8° at the eye. What is the approximate height of object which can be seen by an eye placed at a distance of 1 m from the object?



(*a*) π cm (*b*) 2π cm

(*c*) 4π cm (*d*) 3π cm

17. In the relation $P = \frac{\alpha}{\beta}e^{-\frac{\alpha z}{K\theta}}$ P is pressure, Z is the distance, K is Boltzmann's constant and θ is the temperature. The dimensional formula of α will be:

(*a*) $[M^1L^1T^{-2}]$ (*b*) $[M^1L^2T^1]$

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

18. Consider the equation $\frac{d}{dt}\left(\int \vec{F}\cdot d\vec{S}\right) = A\left(\vec{F}\cdot\vec{p}\right)$ where $\vec{F}$ = force, $\vec{s}$ = displacement, t = time and $\vec{p}$ = momentum. The dimensional formula of A will be :

(*a*) $M^0L^0T^0$ (*b*) ML^0T^0

(*c*) $M^{-1}L^0T^0$ (*d*) $M^0L^0T^{-1}$

19. If P, Q, R are physical quantities, having different dimensions, which of the following combinations can never be a meaningful quantity?

(*a*) $\frac{(P-Q)}{R}$ (*b*) PQ – R

(*c*) $\frac{PQ}{R}$ (*d*) $\frac{(PR-Q^2)}{R}$

20. Given that the displacement of an oscillating particle is given by y = A sin(Bx + Ct + D). The dimensional formula for (ABCD) is:

(*a*) $[M^0L^{-1}T^0]$ (*b*) $[M^0L^0T^{-1}]$

(*c*) $[M^0L^{-1}T^{-1}]$ (*d*) $[M^0L^0T^0]$

21. Force F and density d are related as $F = \frac{\alpha}{\beta + \sqrt{d}}$ then find the dimensions of α:

(*a*) $[M^{1/2}L^{-1/2}T^{-2}]$ (*b*) $[M^{3/2}L^{1/2}T^2]$

(*c*) $[M^{3/2}L^{-1/2}T^{-2}]$ (*d*) $[M^2L^{-1/2}T^2]$

22. Frequency is the function of density (ρ), length (a) and surface tension (T). The value is:

(*a*) $\frac{k\rho^{1/2}a^{3/2}}{\sqrt{T}}$ (*b*) $\frac{k\rho^{3/2}a^{3/2}}{\sqrt{T}}$

(*c*) $\frac{k\rho^{1/2}a^{3/2}}{T^{3/4}}$ (*d*) None of these

23. A liquid of coefficient of viscosity η is flowing steadily through a capillary tube of radius "r" and length "l". If V is volume of liquid flowing per second, the pressure difference "P" at the end of tube is given by:

(*a*) $P = \frac{8\pi l v}{\eta r^4}$ (*b*) $P = \frac{8\eta r^4 l}{\pi v}$

(*c*) $P = \frac{8\eta l v}{\pi r^4}$ (*d*) $P = \frac{8\eta r^4 v}{\pi l}$

24. The mass and volume of a body are 4.237 g and 2.5 cm^3, respectively. The density of the material of the body in correct significant figures is:

(*a*) 1.6048 g cm^{-3} (*b*) 1.69 g cm^{-3}

(*c*) 1.7 g cm^{-3} (*d*) 1.695 g cm^{-3}

25. The length and breadth of a rectangular sheet are (16.2 ± 0.1) cm and (10.1 ± 0.1) cm, respectively. The area of the sheet in appropriate significant figures and error is:

(*a*) 164 ± 3 cm^2 (*b*) 163.62 ± 2.6 cm^2

(*c*) 163.6 ± 2.6 cm^2 (*d*) 163.62 ± 3 cm^2

26. On the basis of dimensions, decide which of the following relations for the displacement of a particle undergoing simple harmonic motion is not correct?

(*a*) $y = a \sin 2\pi t/T$ (*b*) $y = a \sin \frac{vt}{\lambda}$

(*c*) $y = \frac{a}{t} \sin\left(\frac{t}{a}\right)$ (*d*) $y = a\sqrt{2}\left(\sin\frac{2\pi t}{T} - \cos\frac{2\pi t}{T}\right)$

Multiconcept MCQs

1. The relative density of a metal may be found by hanging a block of the metal from a spring balance and nothing that in air, the balance reads (5.00 ± 0.05)N while in water, it reads (4.00 ± 0.05)N. The relative density would be quoted as:

(*a*) 5.00 ± 0.05 (*b*) 5.00 ± 11%

(*c*) 5.00 ± 0.10 (*d*) 5.00 ± 6%

2. The position of the particle moving along Y-axis is given as $y = At^2 - Bt^3$, where y is measured in metre and t in second. Then, the dimensions of B are

(*a*) $[LT^{-2}]$ (*b*) $[LT^{-1}]$

(*c*) $[LT^{-3}]$ (*d*) $[MLT^{-2}]$

3. A physical quantity x is given by $x = \frac{2k^3 l^2}{m\sqrt{n}}$. The percentage error in the measurements of k, l, m and n are 1%, 2%, 3% and 4% respectively. The value of x is uncertain by

(*a*) 8% (*b*) 10%

(*c*) 12% (*d*) None of these

4. It is known that the time of revolution T of a satellite around the earth depends on the universal gravitational constant G, the mass of the earth M, and the radius of the circular orbit R. Obtain an expression for T using dimensional analysis.

(*a*) $2\pi\sqrt{\frac{R^3}{GM}}$ (*b*) $\pi\sqrt{\frac{R^3}{GM}}$

(*c*) $\pi\sqrt{\frac{R}{GM}}$ (*d*) None of these

5. A uniform wire of length L and mass M is stretched between two fixed points, keeping a tension F. A sound of frequency μ is impressed on it. Then the maximum vibrational energy is existing in the wire when μ=

(*a*) $\frac{1}{2}\sqrt{\frac{ML}{F}}$ (*b*) $\sqrt{\frac{FL}{M}}$

(*c*) $2\times\sqrt{\frac{FM}{L}}$ (*d*) $\frac{1}{2}\sqrt{\frac{F}{ML}}$

6. Given: $\text{Force} = \frac{\alpha}{\text{density} + \beta^3}$. What are the dimensions of α, β?

(*a*) $ML^{-2}T^{-2}$, $ML^{-1/3}$ (*b*) $M^2L^4T^{-2}$, $M^{-1/3}L^{-1}$

(*c*) $M^2L^{-2}T^{-2}$, $M^{1/3}L^{-1}$ (*d*) $M^2L^{-2}T^{-2}$, ML^{-3}

7. If E, m, l and G denote energy, mass, angular momentum and gravitational constant respectively, the quantity $\left(\frac{El^2}{m^5G^2}\right)$ has the dimensions of:

(*a*) Mass (*b*) Length

(*c*) Time (*d*) Angle

8. If the units of length , velocity and force are half, then the units of Power will be :

(*a*) Doubled (*b*) Halved

(*c*) $\frac{1}{4}$th (*d*) Remain unaffected

9. Suppose mass, velocity & time were fundamental physical quantities then find the dimensional formula of pressure.

(*a*) $[M^1V^{-1}T^{-2}]$ (*b*) $[M^1V^{-1}T^{-3}]$

(*c*) $[M^1V^{-2}T^{-3}]$ (*d*) $[M^2V^{-2}T^{-3}]$

10. According to Newton, the viscous force acting between liquid layers of area (A) and velocity gradient $\left(\frac{\Delta V}{\Delta Z}\right)$ is given by $F = -\eta A \frac{\Delta V}{\Delta Z}$, where η is constant called coefficient of viscosity. The dimensional formula of η is:

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

(*c*) $[ML^2 T^2]$ (*d*) $[ML^{-1} T^{-1}]$

11. Given that $\int \frac{dx}{\sqrt{2ax - x^2}} = a^n \sin^{-1}\left(\frac{x - a}{a}\right)$ where a = constant, using dimensional analysis, the value of n is-

(*a*) 1

(*b*) –1

(*c*) 0

(*d*) None of the above

NEET Past 10 Years Questions

1. If E and G respectively denote energy and gravitational constant, then E/G has the dimensions of: ***(2021)***

(*a*) $[M][L^{-1}][T^{-1}]$ (*b*) $[M][L^0][T^0]$

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

2. A screw gauge gives the following readings when used to measure the diameter of a wire ***(2021)***

Main scale reading : 0 mm

Circular scale reading : 52 divisions

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

(*a*) 0.026 cm (*b*) 0.26 cm

(*c*) 0.052 cm (*d*) 0.52 cm

3. If force [F], acceleration [A] and time [T] are chosen as the fundamental physical quantities. Find the dimensions of energy. ***(2021)***

(a) $[F]\,[A]\,[T^2]$ (b) $[F]\,[A]\,[T^{-1}]$

(c) $[F]\,[A^{-1}]\,[T]$ (d) $[F]\,[A]\,[T]$

4. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale.

The pitch of the screw gauge is: ***(2020)***

(*a*) 0.25 mm (*b*) 0.5 mm

(*c*) 1.0 mm (*d*) 0.01 mm

5. Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m? ***(2020)***

(*a*) 9.98 m (*b*) 9.980 m

(*c*) 9.9 m (*d*) 9.9801 m

6. Dimensions of stress are : ***(2020)***

(*a*) $[ML^2T^{-2}]$ (*b*) $[ML^0T^{-2}]$

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

7. The intervals measured by a clock given the following readings:

1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s. What is the percentage relative error is the observations?

(2020 Covid Re-NEET)

(*a*) 4% (*b*) 16%

(*c*) 1.6% (*d*) 2%

8. The angle of 1' (minute of arc) in radian is nearly equal to ***(2020 Covid Re-NEET)***

(*a*) 4.85×10^{-4} rad

(*b*) 4.80×10^{-6} rad

(*c*) 1.75×10^{-2} rad

(*d*) 2.91×10^{-4} rad

9. In an experiment, the percentage of error occurred in the measurement of physical quantities A, B, C and D are 1%, 2%, 3% and 4% respectively. Then the maximum percentage of error in the measurement of X,

where $X = \frac{A^2 B^{1/2}}{C^{1/3} D^3}$ will be ***(2019)***

(*a*) $\left(\frac{3}{13}\right)\%$ (*b*) 16%

(*c*) – 10% (*d*) 10%

10. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is ***(2018)***

(*a*) 0.053 cm (*b*) 0.525 cm

(*c*) 0.521 cm (*d*) 0.529 cm

11. A physical quantity of the dimensions of length that can be formed out of c, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]: ***(2017)***

(*a*) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$ (*b*) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$

(*c*) $\frac{1}{c^2}G\frac{e^2}{4\pi\varepsilon_0}$ (*d*) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

12. A student performs an experiment of measuring the thickness of a slab with a vernier caliper whose 50 divisions of the main scale. He noted that zero of the vernier scale is between 7.00 cm and 7.05 cm mark of the main scale and 23^{rd} division of the vernier scale exactly coincides with the main scale. The measured value of the thickness of the given slab using the caliper will be: ***(2017)***

(*a*) 7.73 cm (*b*) 7.23 cm

(*c*) 7.023 cm (*d*) 7.073 cm

13. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are three fundamental constants. Which of the following combinations of these has the dimension of length? ***(2016 - II)***

(*a*) $\sqrt{\frac{hc}{G}}$ (*b*) $\sqrt{\frac{Gc}{h^{3/2}}}$

(*c*) $\frac{\sqrt{hG}}{c^{3/2}}$ (*d*) $\sqrt{\frac{hG}{c^{5/2}}}$

14. If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be: ***(2015)***

(*a*) $[EV^{-1}T^{-2}]$ (*b*) $[EV^{-2}T^{-2}]$

(*c*) $[E^{-2}V^{-1}T^{-3}]$ (*d*) $[EV^{-2}T^{-1}]$

15. If dimension of critical velocity of liquid flowing through a tube are expressed as $v_c \propto [\eta^x \rho^y r^z]$ where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by: ***(2015 - Re)***

(*a*) 1, 1, 1 (*b*) 1, –1, –1

(*c*) –1, –1, 1 (*d*) –1, –1, –1

16. If Force (F), Velocity (V) and Time (T) are taken as fundamental units, then the dimensions of mass are: ***(2014)***

(*a*) $[F\,V\,T^{-1}]$ (*b*) $[F\,V\,T^{-2}]$

(*c*) $[F\,V^{-1}\,T^{-1}]$ (*d*) $[F\,V^{-1}T]$

17. In an experiment four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated as follows $P = \frac{a^3b^2}{cd}$. % error in P is: ***(2013)***

(*a*) 4% (*b*) 14%

(*c*) 10% (*d*) 7%

18. The dimensions of $(\mu_0\varepsilon_0)^{-1/2}$ are: ***(2012 Mains)***

(*a*) $[L^{1/2}T^{-1/2}]$ (*b*) $[L^{-1}T]$

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

19. The damping force on an oscillator is directly proportional to the velocity. The units of the constant of proportionality are: ***(2012 Pre)***

(*a*) $kgms^{-1}$ (*b*) kg/ms

(*c*) kgs^{-1} (*d*) kgs

ANSWER KEY

Topicwise Questions

1. (*b*)	**2.** (*c*)	**3.** (*c*)	**4.** (*b*)	**5.** (*c*)	**6.** (*c*)	**7.** (*a*)	**8.** (*a*)	**9.** (*d*)	**10.** (*b*)
11. (*a*)	**12.** (*a*)	**13.** (*b*)	**14.** (*b*)	**15.** (*a*)	**16.** (*a*)	**17.** (*d*)	**18.** (*c*)	**19.** (*c*)	**20.** (*a*)
21. (*a*)	**22.** (*d*)	**23.** (*a*)	**24.** (*a*)	`**25.** (*b*)	**26.** (*d*)	**27.** (*c*)	**28.** (*d*)	**29.** (*c*)	**30.** (*d*)
31. (*a*)	**32.** (*d*)	**33.** (*a*)	**34.** (*d*)	**35.** (*c*)	**36.** (*c*)	**37.** (*b*)	**38.** (*a*)	**39.** (*d*)	**40.** (*b*)
41. (*c*)	**42.** (*c*)	**43.** (*d*)	**44.** (*d*)	**45.** (*b*)	**46.** (*a*)	**47.** (*d*)	**48.** (*d*)	**49.** (*a*)	**50.** (*b*)
51. (*c*)	**52.** (*a*)	**53.** (*c*)	**54.** (*c*)	**55.** (*a*)	**56.** (*c*)	**57.** (*c*)	**58.** (*b*)	**59.** (*d*)	

Learning Plus

1. (*b*)	**2.** (*a*)	**3.** (*b*)	**4.** (*d*)	**5.** (*c*)	**6.** (*c*)	**7.** (*d*)	**8.** (*c*)	**9.** (*b*)	**10.** (*b*)
11. (*d*)	**12.** (*a*)	**13.** (*a*)	**14.** (*a*)	**15.** (*d*)	**16.** (*a*)	**17.** (*a*)	**18.** (*c*)	**19.** (*a*)	**20.** (*b*)
21. (*c*)	**22.** (*d*)	**23.** (*c*)	**24.** (*c*)	**25.** (*a*)	**26.** (*c*)				

Multiconcept MCQs

1. (*b*)	**2.** (*c*)	**3.** (*c*)	**4.** (*a*)	**5.** (*d*)	**6.** (*c*)	**7.** (*d*)	**8.** (*c*)	**9.** (*b*)	**10.** (*d*)
11. (*c*)									

NEET Past 10 Years Questions

1. (*d*)	**2.** (*c*)	**3.** (*a*)	**4.** (*b*)	**5.** (*a*)	**6.** (*c*)	**7.** (*c*)	**8.** (*d*)	**9.** (*b*)	**10.** (*d*)
11. (*d*)	**12.** (*c*)	**13.** (*c*)	**14.** (*b*)	**15.** (*b*)	**16.** (*d*)	**17.** (*b*)	**18.** (*c*)	**19.** (*c*)	

Units and Measurements

Topicwise Questions

1. (*b*) Magnetic moment = Current × Area = L^2A^1

2. (*c*) As C is added to t, therefore, C has the dimensions of T.

As $\frac{b}{t} = V$, $b = V \times t = LT^{-1} \times T = (L)$

From V = at, $a = \frac{V}{t} = \frac{LT^{-1}}{T} = [LT^{-2}]$

3. (*c*) (a) Work = force x distance = $[MLT^{-2}][L] = [ML^2T^{-2}]$
Torque = force × distance = $[ML^2\,T^{-2}]$

(b) Angular momentum = mvr = $[M][LT^{-1}][L] = [ML^2T^{-1}]$

Planck's constant $= \frac{E}{\nu} = \frac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2L^{-1}]$

(c) Tension = force = $[MLT^{-2}]$

Surface tension $= \frac{\text{force}}{\text{length}} = \frac{[MLT^{-2}]}{[L]} = [ML^0T^{-2}]$

(d) Impulse = force × time = $[MLT^{-2}][T] = [MLT^{-1}]$

Momentum = mass × velocity = $[M][LT^{-1}] = [MLT^{-1}]$

4. (*b*) From the principle of homogeneity $\left(\frac{x}{v}\right)$ and k has dimensions of T.

5. (*c*) A unit-less quantity never has a non-zero dimension, i.e., it is dimensionless.

6. (*c*) Given, Young's modulus $Y = 1.9 \times 10^{11}$ N/m^2

1N = 10^5 dyne

Hence, $Y = 1.9 \times 10^{11} \times 10^5$ dyne/(100)^2 cm^2

We know that 1m = 100 cm

$\therefore Y = 1.9 \times 10^{11} \times 10^5$ dyne/(100)^2 cm^2

$= 1.9 \times 10^{16-4}$ dyne/cm^2

$Y = 1.9 \times 10^{12}$ dyne/cm^2

7. (*a*) A dimensionless quantity may have a unit. For example: angle has a unit but is dimensionless.

8. (*a*) As a × t is dimensionless

$a = \frac{1}{t} = \frac{1}{T} = [T^{-1}]$

Also; $x = \frac{v_0}{a} \Rightarrow v_0 = xa = [LT^{-1}]$

9. (*d*) Surface tension $= \frac{\text{Force}}{\text{Length}} = \frac{[MLT^{-2}]}{[L]} = [ML^0\,T^{-2}]$

Spring constant $= \frac{\text{Force}}{\text{Length}} = \frac{[MLT^{-2}]}{[L]} = [ML^0\,T^{-2}]$.

10. (*b*) $RC = \left(\frac{V}{I}\right)\left(\frac{q}{V}\right) = \frac{q}{I} = \frac{I \times t}{I} = t$

11. (*a*) From; $F = \frac{Gm_1m_2}{r^2}$

$G = \frac{Fr^2}{m_1m_2} = \frac{(MLT^{-2})L^2}{M^2} = [M^{-1}L^3T^{-2}]$

12. (*a*) Magnetic flux (ϕ) = BA = $\left(\frac{F}{I\ell}\right)A$

$= \frac{(MLT^{-2}(L^2))}{AL} = [M^1L^2T^{-2}A^{-1}]$

13. (*b*) We know that energy of radiation, E = hv,

$$[h]=\frac{[E]}{[v]}=\frac{[ML^2T^{-2}]}{[T^{-1}]}=[ML^2T^{-1}]$$

Angular impulse = τdt = ΔL = Change in angular momentum

Hence, dimension of angular impulse

= Dimension of angular momentum = $[ML^2T^{-1}]$.

This is similar to the dimension of Planck's constant *h*.

14. (*b*) Dimensions of work and torque = $[ML^2T^{-2}]$

15. (*a*) $\text{Resistivity}(\rho)=\frac{[R][A]}{[L]}$ where; $R=[ML^2T^{-1}Q^{-2}]$

16. (*a*) $\frac{R}{L}=\frac{V/I}{V\times T/I}=\frac{1}{T}=\text{Frequency}$

17. (*d*) $e=L\frac{di}{dt}$

$$[e]=[ML^2T^{-2}A^{-2}]\left[\frac{A}{T}\right]=\left[\frac{ML^2T^{-2}}{AT}\right]=[ML^2T^{-2}Q^{-1}]$$

18. (*c*) Momentum $[MLT^{-1}]$, Planck's constant $[ML^2T^{-1}]$

19. (*c*) $[X]=[F]\times[\rho]^{1/2}$

$$=[MLT^{-2}]\times\left[\frac{M}{L^3}\right]^{1/2}=[M^{3/2}L^{-1/2}T^{-2}]$$

20. (*a*) $\frac{1}{\sqrt{\mu_0\varepsilon_0}}=C=\text{Velocity of light}$

So dimension of velocity and $\frac{1}{\sqrt{\mu_0\varepsilon_0}}$ is same

21. (*a*) Angle of banking;

$\tan\theta=\frac{V^2}{rg}$ i.e., $\frac{V^2}{rg}$ is dimensionless

22. (*d*) We know that 1 light year = 9.46×10^{11} m = distance that light travels in 1 year with speed 3×10^8 m/s.

23. (*a*) As $Q=mL\Rightarrow[L]=\frac{[Q]}{[m]}=\frac{[ML^2T^{-2}]}{[M]}=[M^0L^2T^{-2}]$

24. (*a*) $V=\sqrt{\frac{\gamma P}{\rho}}$ or $\gamma=\frac{V^2\rho}{P}$

$$[\gamma]=\frac{[LT^{-1}]^2[ML^{-3}]}{[ML^{-1}T^{-2}]}=[M^0L^0T^0]$$

25. (*b*) Here; kx is dimensionless. Hence,

$$[k]=\left[\frac{2\pi}{\lambda}\right]=[M^0L^{-1}T^0]$$

Since (wt – kx) is dimensionless.

26. (*d*) As, $\mu=\frac{\text{Velocity of light in vaccum}}{\text{Velocity of light in medium}}$, hence μ is dimensionless.

Thus, each term on the RHS of given equation should be dimensionless.

$\therefore\frac{\beta}{\lambda^2}$ is dimensionless, i.e., β should have dimensions of λ^2, i.e., area.

27. (*c*) $E=\frac{\text{stress}}{\text{strain}}\Rightarrow E=\text{stress}$ (strain has no dimensions)

28. (*d*) Here, $(\omega t+\phi_0)$ is dimensionless because it is an argument of a trigonometric function.

29. (*c*) According to stefan's law, energy emitted per second per unit area is:

$$E=e\,\sigma\,T^4\Rightarrow[\sigma]=\frac{[ML^2T^{-2}/L^2T]}{[\theta^4]}=[MT^{-3}\theta^{-4}]$$

30. (*d*) $e=L\left[\frac{dI}{dt}\right]$

$$\therefore[L]=\frac{[e][dt]}{[dI]}=\frac{[w/q][dt]}{[dI]}=\frac{[w][dt]}{[q][dI]}=\frac{[w]}{[dI]^2}$$

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

$$[C]=\frac{[q]}{[v]}\Rightarrow\frac{[q^2]}{[w]}\Rightarrow\frac{[A^2T^2]}{[ML^2T^{-2}]}\Rightarrow[M^{-1}L^{-2}T^4A^2]$$

$$[\sqrt{LC}]=\left([ML^2T^{-2}A^{-2}]\times[M^{-1}L^{-2}T^4A^2]\right)^{1/2}$$

$$=[T^2]^{1/2}=[T]\Rightarrow\therefore\left[\frac{1}{\sqrt{LC}}\right]=[T]^{-1}$$

31. (*a*) $W=\frac{1}{2}Kx^2\Rightarrow[K]=\frac{[w]}{[x^2]}=\frac{[ML^2T^{-2}]}{[L^2]}=[MT^{-2}]$

32. (*d*) According to the relation

$L=\frac{nh}{2\pi}=\text{Angular momentum}$

33. (*a*) $F=[M^1L^1T^{-2}]$

$=[(10g)^1(10cm)^1(0.1s)^{-2}]$

$=[(10^{-2}kg)^1(10^{-1}m)^1(10^2s^{-2})]\Rightarrow F=10^{-1}N=0.1\,N$

34. (*d*) Given, fundamental quantities are momentum (p), area(A) and Time (T). We can write energy, $E \propto p^a A^b T^c$, $E = kp^a A^b T^c$

Where k is dimensionless constant of proportionality.

Dimensions of $E = [E] = [ML^2T^{-2}]$ and $[p] = [MLT^{-1}]$

$[A] = [L^2]$

$[T] = [T]$

$[E] = [k]\,[p]^a\,[A]^b\,[T]^c$

Putting all the dimensions, we get

$ML^2T^{-2} = [MLT^{-1}]^a\,[L^2]^b\,[T]^c \Rightarrow M^aL^{2b+a}\,T^{-a+c}$

By principle of homogeneity of dimensions,

$a = 1,\ 2b + a = 2$

$\Rightarrow\quad 2b + 1 = 2$

$\Rightarrow\quad b = 1/2$

$-a + c = -2$

$\Rightarrow\quad c = -2 + a = -2 + 1 = -1$

Hence, $E = pA^{1/2}T^{-1}$

35. (*c*) $F = M^1\,L^1\,T^{-2}$

$\therefore T^2 = \dfrac{M^1\,L^1}{F} \Rightarrow T = M^{1/2}\,L^{1/2}\,F^{-1/2}$

36. (*c*) Let $G = c^x\,g^y\,P^z$

$[M^{-1}L^3T^{-2}] = [LT^{-1}]^x\,[LT^{-2}]^y\,[ML^{-1}T^{-2}]^z$

$= M^z\,L^{x+y-z}\,T^{-x-2y-2z}$

Applying principle of homogeneity of dimensions, we get

$z = -1,\ x + y - z = 3$

$-x - 2y - 2z = -2$

On solving, we get,

$y = 2,\ x = 0 \Rightarrow \therefore\ G = c^0\,g^2\,P^{-1}$

37. (*b*) Let $m \propto E^x\,V^y\,F^z$

By substituting the following dimensions:

$[E] = [ML^2T^{-2}]$, $[V] = [LT^{-1}]$, $[F] = [MLT^{-2}]$

and by equating the both sides

$x = 1,\ y = -2,\ z = 0$, So $[m] = [EV^{-2}]$

38. (*a*) $F = A^\alpha V^\beta \rho^\gamma$

or $[MLT^{-2}] = [L^2]^\alpha\,[LT^{-1}]^\beta\,[ML^{-3}]^\gamma$

$= [M^\gamma\,L^{2\alpha+\beta-3\gamma}\,T^{-\beta}]$

This gives : $\gamma = 1,\ \beta = 2,\ 2\alpha + \beta - 3\gamma = 1$

or $\alpha = 1$; $F = [AV^2\rho]$

39. (*d*) Dimensions of RHS $= \left[\dfrac{M^{-1}L^3T^{-2} \times M}{L^2}\right]^{1/2}$

$= [M^0LT^{-2}]^{1/2} = \dfrac{[L]^{1/2}}{T} \neq$ LHS

$[V_e] = [M^0LT^{-1}]$

Hence; given equation is dimensionally incorrect.

40. (*b*) In 0.06900, the underlined zeros are not significant. Hence, number of significant figures is four.

41. (*c*) $\Delta x = a - b \pm (\Delta a + \Delta b)$

$= 4.19 - 3.25 \pm (0.01 + 0.01)$

$\Rightarrow 0.94 \pm 0.02$ cm

42. (*c*) The sum of the numbers can be calculated as 663.821 arithmetically. The number with least decimal places is 227.2 is correct to only one decimal place.

The final result should, therefore be rounded off to one decimal place i.e., 663.8.

43. (*d*) Percentage error in A $\left(\dfrac{2\Delta a}{a} + \dfrac{3\Delta b}{b} + \dfrac{\Delta c}{c} + \dfrac{1}{2}\Delta\dfrac{d}{d}\right)$

$= \left(2\times1 + 3\times3 + 1\times2 + \dfrac{1}{2}\times2\right)\% = 14\%$

44. (*d*) Rounding off 2.745 to 3 significant figures it would be 2.74 Rounding off 2.735 to 3 significant figures it would be 2.74.

45. (*b*) $\dfrac{\Delta V}{V} = 3\times\dfrac{\Delta r}{r} = 3\times\dfrac{1}{100} = \dfrac{3}{100} = 3\%$

46. (*a*) Given, $A = 2.5\ ms^{-1} \pm 0.5\ ms^{-1}$, $B = 0.10\ s \pm 0.01\ s$

$x = AB = (2.5)\,(0.10) = 0.25$ m,

$\dfrac{\Delta x}{x} = \dfrac{\Delta A}{A} + \dfrac{\Delta B}{B} \Rightarrow \dfrac{0.5}{2.5} + \dfrac{0.01}{0.10} = \dfrac{0.05 + 0.025}{0.25} = \dfrac{0.075}{0.25}$

$\Delta x = 0.075 = 0.08$ m, rounding off to two significant figures.

$AB = (0.25 \pm 0.08)$ m

47. (*d*) Since; $\rho = \dfrac{m}{\pi r^2 L}$

$\therefore \left(\dfrac{\Delta\rho}{\rho}\right)\times100 = \left(\dfrac{\Delta m}{m} + \dfrac{2\Delta r}{r} + \dfrac{\Delta L}{L}\right)\times100$

$= \left(\dfrac{0.003}{0.3} + 2\times\dfrac{0.005}{0.5} + \dfrac{0.06}{6}\right)\times100$

$= (0.01 + 0.02 + 0.01) \times 100 = 4\%$

48. (*d*) $R_1 = (6 \pm 0.3)K\Omega$, $R_2 = (10 \pm 0.2)\ K\Omega$, $R_p = ?$

$$R_p = \frac{R_1R_2}{R_1 + R_2} \quad [\text{Let } (R_1 + R_2) = X]$$

$$\text{or } R_p = \frac{R_1R_2}{X} \Rightarrow R_p = \ln R_1 + \ln R_2 - \ln X$$

$$\text{Differentiating, } \frac{\Delta R_p}{R_p} = \frac{\Delta R_1}{R_1} + \frac{\Delta R_2}{R_2} + \left(-\frac{\Delta x}{x}\right)$$

In addition or subtraction, errors are calculated as follows:

$$\Delta x \text{ is mean } (\Delta R_1 + \Delta R_2) = \Delta x_{mean} = \frac{0.3 + 0.2}{2} = 0.25\Omega$$

$$R_{mean} = \frac{6\Omega + 10\Omega}{2} = 8\Omega \Rightarrow \frac{\Delta x}{x} = \frac{0.25}{8}$$

$$\therefore \text{Total errors} = \frac{0.3}{6} + \frac{0.2}{10} + \frac{0.25}{8}$$

$$= 0.05 + 0.02 + 0.03125 = 0.10125 \qquad \therefore \frac{\Delta R}{R} \approx 10\%$$

49. (*a*) All given measurements are correct upto two decimal places. As here 5.00 mm has the smallest unit and the error in 5.00 mm is least (commonly taken as 0.01 mm if not specified). Hence, 5.00 mm is most precise.

50. (*b*) If, $x = a^n$ then; $\frac{\Delta x}{x} = \pm n\left(\frac{\Delta a}{a}\right)$

51. (*c*) Given : Voltage $V = (100 \pm 5)V$

Current $I = (10 \pm 0.2)A$

According to ohm's law, $V = IR$ or $R = V/I$

Taking log on both sides, $\log R = \log V - \log I$

$$\text{Differentiating, we get; } \frac{\Delta R}{R} = \frac{\Delta V}{V} - \frac{\Delta I}{I}$$

$$\text{For maximum error, } \frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I}$$

Multiplying both sides by 100 for taking percentage,

$$\text{We get, } \frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$$

Percentage error in resistance R

$$= \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$$

$$= \frac{5}{100} \times 100 + \frac{0.2}{10} \times 100 = 7\%$$

52. (*a*) Given length $l = 5$ cm

Now, checking the errors with each option one by one, we get

$\Delta l_1 = 5 - 4.9 = 0.1$ cm $\quad \Delta l_2 = 5 - 4.805 = 0.195$ cm

$\Delta l_3 = 5.25 - 5 = 0.25$ cm $\quad \Delta l_4 = 5.4 - 5 = 0.4$ cm

Error Δl_1 is least.

Hence, 4.9 cm is most precise.

53. (*c*)

54. (*c*) One main scale division, 1 M.S.D = x cm

$$\text{One vernier scale division, 2 V.S.D} = \frac{(n-1)x}{n}$$

Least count = 1 M.S.D – 1 V.S.D

$$= \frac{nx - nx + x}{n} = \frac{x}{n} \text{cm}$$

55 . (*a*) Correct diameter of the thick wire

= M.S.R + (n × LC) – zero error

= 0.2 + (50 × 0.001) – 0.002

= 0.2 + 0.05 – 0.002

= 0.248

Note: We have to subtract the zero error from the reading as here zero error is positive.

56. (c) $10\ VSD = 9MSD,\ 1VSD = \frac{9}{10}MSD$

$$V.C = 1MSD - 1VSD = \left(1 - \frac{9}{10}\right)MSD$$

$$= \frac{1}{10} \times \frac{1}{2} = 0.05mm$$

57. (c) L.C. = 1MSD – 1VSD

0.02 =0.1 – m/n

$$\frac{m}{n} = 0.08\,m$$

58. (*b*) Diameter of wire = find reading – zero error

final reading = 8 × 0.5 mm + 83 × 0.005 mm = 4.415 mm

zero error = 2 × L.C. = 2 × 0.005 mm

59. (*d*) Zero error $= -6 \times \frac{1}{50}\text{mm} = -0.12\,\text{mm}$

L.C = 0.02 mm

Screw gauge reading = 3 + 31 × 0.02 mm

= 3.62 mm

Diameter. ofwire = 3.62 – zero error

= 3.74 mm

Learning Plus

1. (*b*) $P = P_0 \exp(-\alpha t^2)$

As P and P_0 have the same units, therefore αt^2 must be dimensionless for which $\alpha = \frac{1}{T^2} = T^{-2}$

2. (*a*) Length, time and velocity can be deduced from one another. Therefore, they cannot enter into the list of fundamental quantities in any system.

3. (*b*) $\frac{h}{e^2} = \frac{ML^2T^{-1}}{(AT)^2} = ML^2T^{-3}A^{-2}$ = Resistance (ohm)

4. (*d*) $[\varepsilon_0 \times L] = [C]$ $\left(\because c = \frac{\varepsilon A}{d}\right)$

$$\therefore X = \frac{\varepsilon_0 LV}{t} = \frac{CV}{t} = \frac{Q}{t} = \text{current}$$

5. (*c*) $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{d^2}$

$$\therefore [\varepsilon_0] = \frac{[q_1q_2]}{[Fd^2]} = \frac{[IT \times IT]}{[FL^2]} = [F^{-1}L^{-2}T^2I^2]$$

6. (*c*) We know that dimension of

$h = [h] = [ML^2T^{-1}]$; $[c] = [LT^{-1}]$, $[m_e] = M$

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

$$\left[\frac{hc}{G}\right] = \frac{[ML^2T^{-1}][LT^{-1}]}{[M^{-1}L^3T^{-2}]} = [M^2] \qquad M = \sqrt{\frac{hc}{G}}$$

$$\frac{h}{c} = \frac{[ML^2T^{-1}]}{[LT^{-1}]} = [ML] \quad L = \frac{h}{cM} = \frac{h}{c}\sqrt{\frac{G}{hc}} = \frac{\sqrt{Gh}}{c^{3/2}}$$

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

Hence, a, b or d, any can be used to express L, M and T in terms of three chosen fundamental quantities.

7. (*d*) Dimensions in L.H.S and R.H.S are same for II and IV.

8. (*c*) Quantity C has maximum power, irrespective of sign. So it brings maximum error in P.

9. (*b*) Here ; S = (13.8 ± 0.2)m ; t = (4.0 ± 0.3)sec

$$\therefore V = \frac{13.8}{4} = 3.45\,\text{m/sec}$$

Also; $\frac{\Delta V}{V} = \pm\left(\frac{\Delta S}{S} + \frac{\Delta t}{t}\right)$

$$= \pm\left(\frac{0.2}{13.8} + \frac{0.3}{4.0}\right) = \pm 0.0895$$

$\Delta V = \pm\ 0.0895 \times 3.45 = \pm\ 0.3$

V = (3.45 ± 0.3) m/sec

10. (*b*) Here, maximum fraction error is:

$$\frac{\Delta Q}{Q} = \pm\left(n\frac{\Delta x}{x} + \frac{m\Delta y}{y}\right)$$

$\therefore$ Absolute error in Q, i.e.,

$$\Delta Q = \pm\left(n\frac{\Delta x}{x} + \frac{m\Delta y}{y}\right)Q$$

11. (*d*) In the sum or difference of measurements we do not retain significant digits in those places after the decimal in which there were no significant digits in any one of the original values.

12. (*a*) The fundamental frequency is given by $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$

μ = mass per unit length

$$\mu = \rho\pi\frac{D^2}{4}$$

$$\Rightarrow \qquad f = \frac{1}{2L}\sqrt{\frac{T}{\rho\pi\frac{D^2}{4}}} = \frac{1}{LD}\sqrt{\frac{T}{\pi\rho}}$$

$\therefore$ $f \propto \frac{1}{LD}$ (as T, π and ρ are constants)

13. (*a*) Substituting the dimension of G,I, M and E, we get,

$$\text{Dimension of } \frac{GIM^2}{E^2} = \frac{[M^{-1}L^3T^{-2}][MLT^{-1}][M^2]}{[ML^2T^{-2}]^2}$$

= [T] = dimension of time

14. (*a*) We know that, $[e] = [AT]$, $[\varepsilon_0] = [M^{-1}L^{-3}T^4A^2]$,

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

$$\therefore \left[\frac{e^2}{4\pi\varepsilon_0 hc}\right] = \left[\frac{A^2T^2}{M^{-1}L^{-3}T^4A^2 \times ML^2T^{-1} \times LT^{-1}}\right]$$

$$= [M^0L^0T^0]$$

15. (*d*) According to question, $T \propto p^a d^b E^c$

$[M^0L^0T] = k\,[ML^{-1}T^{-2}]^a\,[ML^{-3}]^b\,[ML^2T^{-2}]^c$

Where, k is constant.

On comparing dimensions of similar terms, we have

$[M^0L^0T] = k[M^{a+b+c} L^{-a-3b+2c} T^{-2a-2c}]$

On comparing powers of M, L and T, we have

$0 = a + b + c$ ...(i)

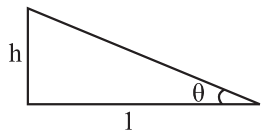
$0 = -a - 3b + 2c$ ...(ii)

$1 = -2a - 2c$ ...(iii)

On solving Eqs. (i), (ii) and (iii), get

$a = -\frac{5}{6}, b = \frac{1}{2}, c = \frac{1}{3}$

16. (*a*) $\frac{h}{1} = \theta$



$\frac{h}{1} = 1.8 \times \frac{\pi}{180} m$

$h = \frac{1.8 \times \pi \times 100}{180} \Rightarrow h = \pi$ cm

17. (*a*) In given equation, $\frac{\alpha z}{K\theta}$ should be dimensionless-

$\therefore \alpha = \frac{K\theta}{z}$

$\alpha = \frac{[ML^2T^{-2}K^{-1} \times K]}{[L]} = [MLT^{-2}]$

18. (*c*) $\left[\frac{d}{dt}\left(\int \vec{F} \cdot d\vec{S}\right)\right] = \left[A\left(\vec{F} \cdot \vec{p}\right)\right] \Rightarrow \left[\frac{FS}{t}\right] = [AFp]$

$\Rightarrow [A] = \left[\frac{S}{pt}\right] = \frac{L}{MLT^{-1} \times T} = M^{-1}$

19. (*a*) Physical quantities having different dimensions cannot be added or subtracted.

As P, Q and R are physical quantites having different dimensions, therefore they can neither be added nor quantity.

20. (*b*) Trigonometric function are dimensionless

$D = M^0L^0T^0 \quad C = \frac{1}{T} = M^0L^0T^{-1} \quad B = \frac{1}{x} = M^0L^{-1}T^0$

A = Dimension of y $= M^0L^1T^0 \quad [ABCD] = M^0L^0T^{-1}$

21. (*c*) $[\alpha] = [F][\sqrt{d}]$

$= MLT^{-2}[ML^{-3}]^{1/2} = [M^{3/2}L^{-1/2}T^{-2}]$

22. (*d*) Let $n = k\rho^a a^b T^c$ where $[\rho] = [ML^{-3}]$,

$[a] = [L]$ and $[T] = [MT^{-2}]$

Comparing dimensions both sides, we get-

$a = -1/2$, $b = -3/2$ and $c = 1/2$

$\therefore \eta = k\rho^{-1/2} a^{-3/2} T^{-1/2} \quad = \frac{k\sqrt{T}}{\rho^{1/2}a^{3/2}}$

23. (*c*) L.H.S = P = $(M^1L^{-1}T^{-2})$

$R.H.S = \frac{8\eta l v}{\pi r^4} = \frac{ML^{-1}T^{-1}(L)(L^3T^{-1})}{L^4} = (ML^{-1}T^{-2})$

24. (*c*) In this question, density should be reported to two significant figures.

$\text{Density} = \frac{4.237\,g}{2.5\,cm^3} = 1.6948$

As rounding off the number, we get density = 1.7

25. (*a*) Given, length $l = (16.2 \pm 0.1)$ cm

Breadth $b = (10.1 \pm 0.1)$ cm

Area $A = l \times b$

$= (16.2\text{ cm}) \times (10.1\text{ cm}) = 163.62\text{ cm}^2$

Rounding off to three significant digits, area A = 164 cm^2

$\frac{\Delta A}{A} = \frac{\Delta l}{l} + \frac{\Delta b}{b} = \frac{0.1}{16.2} + \frac{0.1}{10.1}$

$= \frac{1.01 + 1.62}{16.2 \times 10.1} = \frac{2.63}{163.62}$

$\Delta A = A \times \frac{2.63}{163.62} = 163.62 \times \frac{2.63}{163.62} = 2.63\text{ cm}^2$

$\Delta A = 3\text{ cm}^2$ (By rounding off to one significant figure)

Area, $A = A \pm \Delta A = (164 \pm 3)\text{ cm}^2$.

26. (*c*) Now by principle of homogeneity of dimensions

L.H.S and R.H.S of (a) and (d) will be same and is L.

For (c) [L.H.S] = L $\quad [RHS] = \frac{L}{T} = LT^{-1}$

[L.H.S] ≠ [R.H.S]

Hence, (c) is not correct option.

In option (b) dimension of angle is [vt] i.e., L

$\Rightarrow$ R.H.S = L.L = L^2 and L.H.S = L $\Rightarrow$ L.H.S ≠ R.H.S.

Multiconcept MCQs

1. (*b*) Relative density $= \dfrac{\text{Weight in air}}{\text{Loss of weight in water}}$

$$\rho = \frac{5.00}{1.00} = 5.00$$

$$\frac{d\rho}{\rho} = \frac{0.05}{5.00} + \frac{0.1}{1.00} = 0.11 = 11\%$$

$\rho = 5.00 \pm 11\%$

2. (*c*) As, $Y = At^3 - Bt^3$ $\quad [Y] = [Bt^3]$

$[L] = B[T^3]$ $\quad \therefore [B] = [LT^{-3}]$

3. (*c*) $x = \dfrac{2k^3 l^2}{m\sqrt{n}}$

Percentage error in

$$x, \frac{\Delta x}{x} \times 100 = \left(\frac{3\Delta k}{k} + \frac{2\Delta \ell}{\ell} + \frac{1}{2}\frac{\Delta n}{n} + \frac{\Delta m}{m}\right) \times 100$$

$$\frac{\Delta x}{x} \times 100 = \left[3 \times 1 + 2 \times 2 + \frac{1}{2} \times 4 + 3\right] = 12\%$$

4. (*a*) We have $[T] = [G]^a [M]^b [R]^c$

$$[M]^0 [L]^0 [T]^1 = [M]^{-a} [L]^{3a} [T]^{-2a} \times [M]^b \times [L]^c$$

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

Comparing the exponents

$$\text{For } [T]: 1 = -2a \Rightarrow a = -\frac{1}{2}$$

$$\text{For } [M]: 0 = b - a \Rightarrow b = a = -\frac{1}{2}$$

$$\text{For } [L]: 0 = c + 3a \Rightarrow c = -3a = -\frac{1}{2}$$

Putting the values we get

$$T \propto G^{-1/2} M^{-1/2} R^{3/2} \propto \sqrt{\frac{R^3}{GM}}$$

The actual expression is $T = 2\pi\sqrt{\dfrac{R^3}{GM}}$

5. (*d*) $m \propto (F)^a (M)^b (L)^c$

$T^{-1} = (MLT^{-2})^a (M)^b (L)^c$

$T^{-1} = M^{a+b} L^{a+c} T^{-2a}$

$a + b = 0$ $\quad \boxed{b = \frac{-1}{2}}$ $\quad a + c = 0$ $\quad \boxed{c = \frac{-1}{2}}$

$-2a = -1$ $\quad \boxed{a = \frac{1}{2}}$ $\quad \mu = k F^{1/2} M^{-1/2} L^{-1/2}$

$$\mu = k\sqrt{\frac{F}{ML}}$$

6. (*c*) β^3 = density $= M^1L^{-3}$ $\quad \beta = M^{1/3}L^{-1}$

Also; α = force × density

$= MLT^{-2} \times M^1L^{-3} = [M^2L^{-2}T^{-2}]$

7. (*d*) $\therefore \left[\dfrac{El^2}{m^5G^2}\right] = \dfrac{[ML^2T^{-2}][M^2L^4T^{-2}]}{[M^5][M^{-2}L^6T^{-4}]} = [M^0L^0T^0]$

As angle has no dimensions, therefore $\dfrac{El^2}{m^5G^2}$ has the same dimensions as that of angle.

8. (*c*) $P = L^a V^b F^c$

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

$c = 1$ $\quad 2 = a + b + c$ $\quad a + b = 1$

$-3 = -b - 2c$ $\quad a = 0$

$b = 1$

$P = V^1F^1$

9. (*b*) $[P] = M^xV^yT^z$

$$\frac{MLT^{-2}}{L^2} = M^x\left(\frac{L}{T}\right)^y T^z$$

$ML^{-1}T^{-2} = M^xL^yT^{z-y}$

$\Rightarrow x = 1, y = -1$ $\quad z - y = -2 \Rightarrow z = -2 + y = -3$

10. (*d*) Dimensions of velocity gradient

$$\frac{\Delta V}{\Delta Z} = \frac{[LT^{-1}]}{[L]} = [T^{-1}]$$

Given $F = -\eta\dfrac{\Delta V}{\Delta Z}$

$$\eta = \frac{F}{(A)\left(\frac{\Delta V}{\Delta Z}\right)} = \frac{[MLT^{-2}]}{[L^2][T^{-1}]} = [ML^{-1}T^{-1}]$$

11. (*c*) The integral on LHS is in the form of log x, which is a number. Hence; a^n must be a number, for which $n = 0$.

NEET Past 10 Years Questions

1. (*d*) E = energy = $[ML^2T^{-2}]$

G = Gravitational constant = $[M^{-1}L^3T^{-2}]$

So, $\frac{E}{G} = \frac{[E]}{[G]} = \frac{ML^2T^{-2}}{M^{-1}L^3T^{-2}} = [M^2L^{-1}T^0]$

2. (*c*) L.C. = $\frac{\text{Pitch}}{\text{CSD}}$

$= \frac{1\text{mm}}{100} = 0.01\text{m} = 0.001\text{cm}$

Radius = M.S. + n(L.C.)

= 0 + 52 (0.001)

= 0.052 cm

3. (*a*) $E \propto F^a A^b T^c$

$[M^1L^2T^{-2}] \propto [M^1L^{-2}]^a [LT^{-2}]^b [T]^c$

a = 1

a + b = 2 ⇒ b = 1

–2a – 2b + c = –2

⇒ c = 2

a = 1 b = 1 c = 2

$E \propto [F]\,[A]\,[T^{+2}]$

4. (*b*) Least count $= \frac{\text{Pitch}}{\text{Number of divisions on circular scale}}$

$\Rightarrow 0.01\text{mm} = \frac{\text{Pitch}}{50}$

⇒ pitch = 0.5 mm.

5. (*a*) In subtraction the number of decimal places in the result should be equal to the number of decimal places of that term in the operation which contain lesser number of decimal places.

$$\begin{array}{r} 9.99 \\ -0.0099 \\ \hline 9.98 \end{array} \rightarrow \text{3 significant figures.}$$

6. (*c*) Stress $= \frac{\text{Force}}{\text{Area}}$

$= \frac{M^1L^1T^{-2}}{L^2}$

Stress = $M^1L^{-1}T^{-2}$

7. (*c*) Mean of given observations

$= \frac{1.25 + 1.24 + 1.27 + 1.21 + 1.28}{5} = 1.25$ sec

Mean of errors

$= \frac{0 + 0.01 + 0.02 + 0.04 + 0.03}{5}$

$= \frac{0.1}{5}$

% error $= \frac{0.1 \times 100}{5 \times 1.25} = 1.6\%$

8. (*d*) 1 minute of arc $= 1' = \left(\frac{1}{60}\right)^0 = \frac{1}{60} \times \frac{\pi}{180}$ radian

= 2.91×10^{-4} radian.

9. (*b*) $X = \frac{A^2 B^{\frac{1}{2}}}{C^{\frac{1}{3}} D^3}$

%error, $\frac{\Delta X}{X} \times 100 = 2\frac{\Delta A}{A} \times 100 + \frac{1}{2}\frac{\Delta B}{B} \times 100 + \frac{1}{3}\frac{\Delta C}{C} \times 100 + 3\frac{\Delta D}{D} \times 100$

= 2% + 1% + 1% + 12%

= 16%

10. (*d*) Reading = MSR + (n × LC) + zero error

= 0.5 + (25 × 0.001) + 0.004

= 0.529 cm

11. (*d*) $L = [c]^a [G]^b \left[\frac{e^2}{4\pi\varepsilon_0}\right]^c$

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

$= L^{a + 3b + 3c} T^{-a - 2b - 2c} M^{-b + c}$

a + 3b + 3c = 1; – a –2b –2c = 0; – b + c = 0

$b = \frac{1}{2}$ $\quad c = \frac{1}{2}$ $\quad \downarrow$

a = –2

$L = c^{-2} G^{\frac{1}{2}} \left[\frac{e^2}{4\pi\varepsilon_0}\right]^{\frac{1}{2}}$

$L = \frac{1}{c^2}\left[G \frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

12. (*c*) Least count = 1MSD – 1VSD

$$= 5\times10^{-2} - \frac{49}{50}\times5\times10^{-2}$$

Thickness = 7 + 23 × 10^{-3} = 7.023 cm

13. (*c*) $\ell \propto h^x G^y c^z$

$$M^0L^1T^0 = \left(ML^2T^{-1}\right)^x\left(M^{-1}L^3T^{-2}\right)^y\left(LT^{-1}\right)^z$$

$$= M^{x-y}L^{2x+3y+z}T^{-x-2y-z}$$

Equating:

$$\left.\begin{array}{l} x-y=0 \\ 2x+3y+z=1 \\ -x-2y-z=0 \end{array}\right\} \begin{array}{l} \Rightarrow x=\frac{1}{2}; y=\frac{1}{2}; z=-\frac{3}{2} \\ \Rightarrow \ell \propto \frac{\sqrt{hG}}{c^{3/2}} \end{array}$$

14. (*b*) S.T $\propto [E]^a [V]^b [T]^c$

$\propto [ML^2T^{-2}]^a [LT^{-1}]^b [T]^c$

$MT^{-2} \propto M^a L^{2a+b} T^{-2a-b+c}$

On comparing both sides

2a + b = 0 , –2a – b + c = –2

a = 1, b = –2, c = –2

we get

$ST = EV^{-2} T^{-2}$

15. (*b*) $\nu_c \propto \left[\eta^x\rho^y r^z\right]$

$$\left[L^1T^{-1}\right] \propto \left[M^1L^{-1}T^{-1}\right]^x\left[M^1L^{-3}\right]^y\left[L^1\right]^z$$

$$\left[L^1T^{-1}\right] \propto \left[M^{x+y}\right]\left[L^{-x-3y+z}\right]\left[T^{-x}\right]$$

Taking comparison on both size

x + y = 0, –x – 3y + z = 1, –x = –1

x = 1, y = –1, z = –1

16. (*d*) $[\text{Mass}] = \left[\frac{\text{Force}}{\text{Acceleration}}\right] = \left[\frac{\text{Force}}{\text{Velocity/time}}\right]$

$$= \left[FV^{-1}T\right]$$

17. (*b*) $P = \frac{a^3b^2}{cd} \Rightarrow \frac{\Delta P}{P} = \pm\left(3\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{\Delta d}{d}\right)$

$$= \pm\left(3\times1 + 2\times2 + 3 + 4\right) \Rightarrow \pm14\%$$

18. (*c*) Speed of light, $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = \left[LT^{-1}\right]$

19. (*c*) Let F = kv

$$[k] = \left[\frac{F}{v}\right] = \left[\frac{MLT^{-2}}{LT^{-1}}\right] = \left[MT^{-1}\right]$$

Hence units of k is kgs^{-1}