01

Units and Measurements

TOPIC 1
Units

01 The angle of 1′ (minute of arc) in radian is nearly equal to **[NEET (Oct.) 2020]**

(a) 2.91×10^{-4} rad (b) 4.85×10^{-4} rad
(c) 4.80×10^{-6} rad (d) 1.75×10^{-2} rad

Ans. *(a)*

1 minute $= \frac{1}{60}$ degree $= \frac{1}{60} \times \frac{\pi}{180}$ rad

$= 2.91 \times 10^{-4}$ rad

02 The unit of thermal conductivity is : **[NEET (National) 2019]**

(a) J m^{-1} K^{-1}
(b) W m K^{-1}
(c) W m^{-1} K^{-1}
(d) J m K^{-1}

Ans. *(c)*

The rate of heat flow through a conductor of length L and area of cross-section A is given by

$$\frac{dQ}{dt} = KA\frac{\Delta T}{L} \text{ J/s or watt}$$

where, K = coefficient of thermal conductivity and

ΔT = change in temperature

$$\Rightarrow \quad K = \frac{L}{A\Delta T}\frac{dQ}{dt}$$

$$\therefore \text{Unit of } K = \frac{\text{metre}}{(\text{metre})^2 \times \text{kelvin}} \times \text{watt}$$

$$= \text{Wm}^{-1}\text{K}^{-1}$$

03 The unit of permittivity of free space, ε_0 is **[CBSE AIPMT 2004]**

(a) coulomb/newton-metre
(b) newton - metre^2 / coulomb^2
(c) coulomb^2 /newton -metre^2
(d) coulomb^2 / (newton - metre)^2

Ans. *(c)*

According to Coulomb's law, the electrostatic force

$$F = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1q_2}{r^2}$$

q_1 and q_2 = charges, r = distance between charges

and ε_0 = permittivity of free space

$$\Rightarrow \quad \varepsilon_0 = \frac{1}{4\pi} \times \frac{q_1q_2}{r^2F}$$

Substituting the units for q, r and F, we obtain unit of ε_0

$$= \frac{\text{coulomb} \times \text{coulomb}}{\text{newton-(metre)}^2}$$

$$= \frac{(\text{coulomb})^2}{\text{newton-(metre)}^2}$$

04 The value of Planck's constant in SI unit is **[CBSE AIPMT 2002]**

(a) 6.63×10^{-31} J-s
(b) 6.63×10^{-30} kg - m / s
(c) 6.63×10^{-32} kg - m^2
(d) 6.63×10^{-34} J - s

Ans. *(d)*

The value of Planck's constant is 6.63×10^{-34} and J-s is unit of the Planck's constant.

05 In a particular system, the unit of length, mass and time are chosen to be 10 cm, 10 g and 0.1 s respectively. The unit of force in this system will be equivalent to **[CBSE AIPMT 1994]**

(a) 0.1 N (b) 1 N (c) 10 N (d) 100 N

Ans. *(a)*

Force $F = [\text{MLT}^{-2}]$

$= (10 \text{ g})(10 \text{ cm})(0.1 \text{ s})^{-2}$

Changing these units into MKS system

$$F = (10^{-2} \text{ kg})(10^{-1} \text{ m})(10^{-1} \text{ s})^{-2}$$

$$= 10^{-1} \text{ N} = 0.1 \text{ N}$$

TOPIC 2
Errors in Measurement and Significant Figure

06 A screw gauge gives the following readings when used to measure the diameter of a wire

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 **[NEET 2021]**

(a) 0.52 cm
(b) 0.026 cm
(c) 0.26 cm
(d) 0.052 cm

Ans. *(d)*

Given, the main scale reading, MSR = 0

The circular scale reading, CSR = 52 divisions

Now, we shall determine the least count of the screw gauge,

$$\text{LC} = \frac{p}{n}$$

Here, p is the pitch of the screw,

n is the number of circular divisions in one complete revolution.

$$\text{LC} = \frac{1}{100} \text{ mm}$$

$\Rightarrow$ LC = 0.01 mm

$\Rightarrow$ LC = 0.001 cm

Thus, the least count of the screw gauge is 0.001 cm.

Therefore, diameter of the wire of screw gauge,

$D = \text{MSR} + (\text{CSR} \times \text{LC})$

$\Rightarrow D = 0 + (52 \times 0.001)$

$\Rightarrow D = 0.052$ cm

07 Time intervals measured by a clock give 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 of the observations?

[NEET (Oct.) 2020]

(a) 2% (b) 4% (c) 16% (d) 1.6%

Ans. *(d)*

Mean time interval

$$\bar{T} = \frac{1.25 + 1.24 + 1.27 + 1.21 + 1.28}{5}$$

$$\Rightarrow \quad = \frac{6.25}{5} = 1.25 \text{ s}$$

Mean absolute error,

$$\Delta\bar{T} = \frac{|\Delta T_1| + |\Delta T_2| + |\Delta T_3| + |\Delta T_4| + |\Delta T_5|}{5}$$

$$\Rightarrow = \frac{|1.25 - 1.25| + |1.25 - 1.24| + |1.25 - 1.27| + |1.25 - 1.21| + |1.25 - 1.28|}{5}$$

$$\Rightarrow = \frac{0 + 0.01 + 0.02 + 0.04 + 0.03}{5}$$

$$= \frac{0.1}{5} = 0.02 \text{ s}$$

$\therefore$ Percentage relative error $= \frac{\Delta\bar{T}}{T} \times 100$

$$= \frac{0.02}{1.25} \times 100 = 1.6\%$$

08 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

[NEET (Sep.) 2020]

(a) 0.25 mm (b) 0.5 mm

(c) 1.0 mm (d) 0.01 mm

Ans. *(b)*

Given, least count = 0.01 mm

Number of divisions on circular scale = 50

Pitch of the screw gauge = least count × number of divisions on circular scale

$$= 0.01 \times 50 = 0.5 \text{ mm}$$

Hence, correct option is (b).

09 Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m?

[NEET (Sep.) 2020]

(a) 9.98 m (b) 9.980 m

(c) 9.9 m (d) 9.9801 m

Ans. *(a)*

The difference between 9.99 m and 0.0099 m is

$$= 9.99 - 0.0099 = 9.9801 \text{ m}$$

Taking significant figures into account, as both the values has two significant figures after decimal.

So, their difference will also have two significant figures after decimal, i.e. 9.98 m.

Hence, correct option is (a).

10 The main scale of a vernier calliper has n divisions/cm. n divisions of the vernier scale coincide with $(n-1)$ divisions of main scale. The least count of the vernier callipers is **[NEET (Odisha) 2019]**

(a) $\frac{1}{(n+1)(n-1)}$ cm (b) $\frac{1}{n}$ cm

(c) $\frac{1}{n^2}$ cm (d) $\frac{1}{n(n+1)}$ cm

Ans. *(c)*

As it is given that n divisions of vernier scale coincide with $(n-1)$ divisions of main scale i.e.

$$n(VSD) = (n-1)MSD$$

$$\Rightarrow \quad 1VSD = \frac{(n-1)}{n} MSD \quad \text{...(i)}$$

The least count is the difference between one main scale division (MSD) and one vernier scale division (VSD).

$\therefore$ Least Count $(LC) = 1MSD - 1VSD$

$$= 1MSD - \frac{(n-1)}{n} MSD \text{ [From Eq. (i)]}$$

$$= \left(1 - \frac{(n-1)}{n}\right) MSD = \frac{1}{n} MSD$$

Here, $1MSD = \frac{1}{n}$ cm

$$\Rightarrow \quad LC = \frac{1}{n} \times \frac{1}{n} \text{ cm} = \frac{1}{n^2} \text{ cm}$$

11 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

[NEET 2018]

(a) 0.053 cm (b) 0.525 cm

(c) 0.521 cm (d) 0.529 cm

Ans. *(d)*

Given, least count of screw gauge, LC = 0.001 cm

Main scale reading,

MSR = 5 mm = 0.5 cm

Number of coinciding divisions on the circular scale, i.e. Vernier scale reading, VSR = 25

Here, zero error = –0.004 cm

Final reading obtained from the screw gauge is given as

= MSR + VSR × LC – zero error

Final reading from the screw gauge

$$= 0.5 + 25 \times 0.001 - (-0.004)$$

$$= 0.5 + 0.025 + 0.004$$

$$= 0.5 + 0.029$$

$$= 0.529 \text{ cm}$$

Thus, the diameter of the ball is 0.529 cm.

12 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 $P = \frac{a^3 b^2}{cd}$%. Error in P is

[NEET 2013]

(a) 14% (b) 10%

(c) 7% (d) 4%

Ans. *(a)*

As given, $P = \frac{a^3 b^2}{cd}$

$$\therefore \quad \frac{\Delta P}{P} \times 100$$

$$= \left(\frac{3\Delta a}{a} + \frac{2\Delta b}{b} + \frac{\Delta c}{c} + \frac{\Delta d}{d}\right) \times 100$$

$$= 3\frac{\Delta a}{a} \times 100 + 2\frac{\Delta b}{b} \times 100 + \frac{\Delta c}{c} \times 100 + \frac{\Delta d}{d} \times 100$$

$$= 3 \times 1 + 2 \times 2 + 3 + 4$$

$$= 3 + 4 + 3 + 4 = 14\%$$

13 If the error in the measurement of radius of a sphere is 2%, then the error in the determination of volume of the sphere will be

[CBSE AIPMT 2008]

(a) 4% (b) 6%

(c) 8% (d) 2%

Ans. *(b)*

Volume of a sphere, $V = \frac{4}{3}\pi r^3$

$$\therefore \quad \frac{\Delta V}{V} \times 100 = \frac{3 \times \Delta r}{r} \times 100$$

Here $\frac{\Delta r}{r} \times 100 = 2\%$

$$\therefore \quad \frac{\Delta V}{V} \times 100 = 3 \times 2\% = 6\%$$

14 The density of a cube is measured by measuring its mass and length of its sides. If the maximum error in the measurement of mass and length are 4% and 3% respectively, the maximum error in the measurement of density will be **[CBSE AIPMT 1996]**

(a) 7% (b) 9%
(c) 12% (d) 13%

Ans. *(d)*

As density $\rho = \frac{m}{V} = \frac{m}{l^3}$

$$\therefore \frac{\Delta\rho}{\rho}\times 100 = \pm\left(\frac{\Delta m}{m} + 3\frac{\Delta l}{l}\right)\times 100\%$$

$$= \pm(4 + 3\times 3) = \pm 13\%$$

15 The percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in kinetic energy obtained by measuring mass and speed, will be **[CBSE AIPMT 1995]**

(a) 12% (b) 10%
(c) 8% (d) 2%

Ans. *(c)*

Kinetic energy $K = \frac{1}{2}mv^2$

$$\therefore \frac{\Delta K}{K}\times 100 = \frac{\Delta m}{m}\times 100 + 2\times\frac{\Delta v}{v}\times 100$$

Here, $\frac{\Delta m}{m}\times 100 = 2\%$

$$\Rightarrow \frac{\Delta v}{v}\times 100 = 3\%$$

$$\therefore \frac{\Delta K}{K}\times 100 = 2\% + 2\times 3\% = 8\%$$

16 In a vernier callipers N divisions of vernier scale coincide with $N-1$ divisions of main scale (in which length of one division is 1 mm). The least count of the instrument should be **[CBSE AIPMT 1994]**

(a) N (b) $N-1$
(c) $\frac{1}{10N}$ (d) $\frac{1}{(N-1)}$

Ans. *(c)*

As given N VSD $= (N-1)$ MSD

VSD = Vernier scale division

MSD = Main scale division

$$1\text{ VSD} = \left(\frac{N-1}{N}\right)\text{MSD}$$

LC = least count = 1 MSD − 1 VSD

$$\text{LC} = \left(1 - \frac{N-1}{N}\right)\text{MSD}$$

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

17 A certain body weighs 22.42 g and has a measured volume of 4.7 cc. The possible error in the measurement of mass and volume are 0.01 g and 0.1 cc. Then, maximum error in the density will be **[CBSE AIPMT 1991]**

(a) 22% (b) 2% (c) 0.2% (d) 0.02%

Ans. *(b)*

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\rho = \frac{m}{V}$$

$$\therefore \frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \frac{\Delta V}{V}$$

Here, $\Delta m = 0.01, m = 22.42$

$\Delta V = 0.1, V = 4.7$

$$\therefore \frac{\Delta\rho}{\rho} = \left(\frac{0.01}{22.42} + \frac{0.1}{4.7}\right)\times 100 = 2\%$$

TOPIC 3
Dimensions

18 If force $[F]$, acceleration $[a]$ and time $[T]$ are chosen as the fundamental physical quantities. Find the dimensions of energy. **[NEET 2021]**

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

Ans. *(b)*

Given, fundamental physical quantities are force $[F]$, acceleration $[a]$ and time $[T]$.

Now, we shall determine the dimensions of the energy.

Energy depends on force, acceleration and time as,

$$[E] = [F]^a[a]^b[T]^c$$

$$\Rightarrow [ML^2T^{-2}] = [MLT^{-2}]^a[LT^{-2}]^b[T]^c$$

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

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

$a = 1, a + b = 2$

and $-2a - 2b + c = -2$

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

$\Rightarrow -2(1) - 2(1) + c = -2 \Rightarrow c = 2$

The dimensions of the energy are $[F^1][a]^1[T]^2$.

19 If E and G respectively denote energy and gravitational constant. then $\frac{E}{G}$ has the dimensions of **[NEET 2021]**

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

Ans. *(a)*

The dimensions of energy

$$[E] = [F]\cdot[d]$$

$$\Rightarrow [E] = [MLT^{-2}][L] \Rightarrow [E] = [ML^2T^{-2}]$$

As we know that, the expression of gravitational force,

$$F = \frac{GM_1M_2}{r^2} \Rightarrow G = \frac{Fr^2}{M_1M_2}$$

$$\therefore [G] = \frac{[F][r^2]}{[M_1][M_2]} \Rightarrow [G] = \frac{[MLT^{-2}][L]^2}{[M][M]}$$

$$\Rightarrow [G] = [M^{-1}L^3T^{-2}]$$

The dimensions of

$$\frac{E}{G} = \frac{[ML^2T^{-2}]}{[M^{-1}L^3T^{-2}]} \Rightarrow \left[\frac{E}{G}\right] = [M^2L^{-1}T^0]$$

20 Dimensions of stress are **[NEET (Sep.) 2020]**

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

Ans. *(c)*

$$\because \text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$\therefore \text{Dimensions of stress} = \frac{[MLT^{-2}]}{[L^2]}$$

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

Hence, correct option is (c).

21 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] **[NEET 2017]**

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

Ans. *(a)*

As force $F = \frac{e^2}{4\pi\varepsilon_0 r^2} \Rightarrow \frac{e^2}{4\pi\varepsilon_0} = r^2\cdot F$

Putting dimensions of r and F, we get,

$$\Rightarrow \left[\frac{e^2}{4\pi\varepsilon_0}\right] = [ML^3T^{-2}] \quad \text{...(i)}$$

Also, force, $F = \frac{Gm^2}{r^2}$

$\Rightarrow \quad [G] = \frac{[MLT^{-2}][L^2]}{[M^2]}$

$\Rightarrow \quad [G] = [M^{-1}L^3T^{-2}]$ ...(ii)

and $\left[\frac{1}{c^2}\right] = \frac{1}{[L^2T^{-2}]} = [L^{-2}T^2]$ ...(iii)

Now, checking optionwise,

$= \frac{1}{c^2}\left(\frac{Ge^2}{4\pi\varepsilon_0}\right)^{1/2} = [L^{-2}T^2][L^6T^{-4}]^{1/2} = [L]$

22 If energy (E), velocity (v) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be **[CBSE AIPMT 2015]**

(a) $[Ev^{-2}T^{-1}]$ (b) $[Ev^{-1}T^{-2}]$
(c) $[Ev^{-2}T^{-2}]$ (d) $[E^{-2}v^{-1}T^{-3}]$

Ans. *(c)*

We know that

Surface tension $(S) = \frac{\text{Force}[F]}{\text{Length}[L]}$

So, $[S] = \frac{[MLT^{-2}]}{[L]} = [ML^0T^{-2}]$

Energy (E) = Force × displacement

$\Rightarrow \quad [E] = [ML^2T^{-2}]$

Velocity $(v) = \frac{\text{displacement}}{\text{time}}$

$\Rightarrow \quad [v] = [LT^{-1}]$

As, $S \propto E^a v^b T^c$

where, a, b, c are constants.

From the principle of homogeneity,

$[LHS] = [RHS]$

$\Rightarrow \quad [ML^0T^{-2}] = [ML^2T^{-2}]^a[LT^{-1}]^b[T]^c$

$\Rightarrow \quad [ML^0T^{-2}] = [M^aL^{2a+b}T^{-2a-b+c}]$

Equating the power on both sides, we get

$a = 1, 2a + b = 0, b = -2$

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

$\Rightarrow \quad c = (2a + b) - 2 = 0 - 2 = -2$

So $[S] = [Ev^{-2}T^{-2}] = [Ev^{-2}T^{-2}]$

23 If dimensions of critical velocity v_c of a liquid flowing through a tube are expressed as $[\eta^x \rho^y r^z]$, 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 **[CBSE AIPMT 2015]**

(a) 1, – 1, – 1 (b) – 1, – 1, 1
(c) – 1, – 1, – 1 (d) 1, 1, 1

Ans. *(a)*

Key Concept According to principle of homogeneity of dimension states that, a physical quantity equation will be dimensionally correct, if the dimensions of all the terms occurring on both sides of the equations are same.

Given critical velocity of liquid flowing through a tube are expressed as

$v_c \propto \eta^n \rho^y r^z$

Coefficient of viscosity of liquid,

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

Density of liquid, $\rho = [ML^{-3}]$

Radius of a tube $r = [L]$

Critical velocity of liquid $v_c = [ML^0T^{-1}]$

$\Rightarrow [M^0L^1T^{-1}] = [ML^{-1}T^{-1}]^x[ML^{-3}]^y[L]^z$

$[M^0L^1T^{-1}] = [M^{x+y}L^{-x-3y+z}T^{-x}]$

Comparing exponents of M, L and L, we get

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

$\Rightarrow \quad z = -1, x = 1, y = -1$

24 If force (F), velocity (v) and time (T) are taken as fundamental units, then the dimensions of mass are **[CBSE AIPMT 2014]**

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

Ans. *(d)*

We know that

$F = ma$

$\Rightarrow \quad F = \frac{mv}{t} \quad \Rightarrow \quad m = \frac{Ft}{v}$

$[M] = \frac{[F][T]}{[v]} = [Fv^{-1}T]$

25 The dimensions of $(\mu_0\varepsilon_0)^{-1/2}$ are **[CBSE AIPMT 2012]**

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

Ans. *(c)*

$(\mu_0\varepsilon_0)^{-1/2}$ is the expression for velocity of light.

As $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

So, dimension of $c = [LT^{-1}]$

26 The dimensions of $\frac{1}{2}\varepsilon_0 E^2$, where ε_0 is permittivity of free space and E is electric field, are **[CBSE AIPMT 2010]**

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

Ans. *(b)*

As we know that,

Dimension of $\varepsilon_0 = [M^{-1}L^{-3}T^4A^2]$

Dimension of $E = [MLT^{-3}A^{-1}]$

So, dimension of

$\frac{1}{2}\varepsilon_0 E^2 = [M^{-1}L^{-3}T^4A^2] \times [MLT^{-3}A^{-1}]^2$

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

27 If the dimensions of a physical quantity are given by $[M^aL^bT^c]$, then the physical quantity will be **[CBSE AIPMT 2009]**

(a) pressure if $a = 1, b = -1, c = -2$
(b) velocity if $a = 1, b = 0, c = -1$
(c) acceleration if $a = 1, b = 1, c = -2$
(d) force if $a = 0, b = -1, c = -2$

Ans. *(a)*

(i) Dimensions of velocity $= [M^0L^1T^{-1}]$
Here, $a = 0, b = 1, c = -1$

(ii) Dimensions of acceleration $= [M^0L^1T^{-2}]$
Here, $a = 0, b = 1, c = -2$

(iii) Dimensions of force $= [M^1L^1T^{-2}]$
Here, $a = 1, b = 1, T = -2$

(iv) Dimensions of pressure $= [M^1L^{-1}T^{-2}]$

$\therefore$ Here, $a = 1, b = -1, c = -2$

$\therefore$ The physical quantity is pressure.

28 Which two of the following five physical parameters have the same dimensions? **[CBSE AIPMT 2008]**

(i) Energy density
(ii) Refractive index
(iii) Dielectric constant
(iv) Young's modulus
(v) Magnetic field

(a) (ii) and (iv) (b) (iii) and (v)
(c) (i) and (iv) (d) (i) and (v)

Ans. *(c)*

Energy density $= \frac{\text{Energy}}{\text{Volume}} \Rightarrow u = \frac{E}{V}$

Dimensions of $u = \frac{\text{Dimensions of } E}{\text{Dimensions of } V}$

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

Refractive index is a dimensionless quantity. Dielectric constant is a dimensionless quantity.

Young's modulus

$= \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{F/A}{\Delta l/l} = [ML^{-1}T^{-2}]$

Magnetic field $= \frac{\text{Force}}{\text{Charge} \times \text{Velocity}} = \frac{F}{qv}$

$= \frac{[MLT^{-2}]}{[AT][LT^{-1}]} = [MT^{-2}A^{-1}]$

29 Dimensions of resistance in an electrical circuit, in terms of dimension of mass M, of length L, of time T and of current I, would be **[CBSE AIPMT 2007]**

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

Ans. *(d)*

According to Ohm's law, $V \propto I$

and $V = IR$

Resistance, $R = \dfrac{\text{Potential difference}}{\text{Current}}$

$= \dfrac{V}{i} = \dfrac{W}{qi}$

$\left(\because \text{Potential difference is equal to the work done per unit charge}\right)$

So, dimensions of R

$= \dfrac{\text{Dimensions of work}}{\text{Dimensions of charge} \times \text{Dimensions of current}}$

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

30 The velocity v of a particle at time t is given by $v = at + \dfrac{b}{t+c}$, where a, b and c are constants. The dimensions of a, b and c are respectively **[CBSE AIPMT 2006]**

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

Ans. *(a)*

The given expression is

$v = at + \dfrac{b}{t+c}$

From principle of homogeneity

$[a][t] = [v]$

$[a] = \dfrac{[v]}{[t]} = \dfrac{[LT^{-1}]}{[T]} = [LT^{-2}]$

Similarly, $[c] = [t] = [T]$

Further, $\dfrac{[b]}{[t+c]} = [v]$

or $[b] = [v][t+c]$

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

31 The ratio of the dimensions of Planck's constant and that of the moment of inertia is the dimension of **[CBSE AIPMT 2005]**

(a) frequency
(b) velocity
(c) angular momentum
(d) time

Ans. *(a)*

Energy carried by photon is given by

$E = h\nu$

$\Rightarrow \quad h = \text{Planck's constant} = \dfrac{E}{\nu}$

$\therefore \quad [h] = \dfrac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$

and $\quad I = \text{moment of inertia} = MR^2$

$\Rightarrow [I] = [ML^2]$

Hence, $\dfrac{[h]}{[I]} = \dfrac{[ML^2T^{-1}]}{[ML^2]} = [T^{-1}]$

$= \dfrac{1}{[T]} =$ dimension of frequency

Alternative

$\dfrac{h}{I} = \dfrac{E/\nu}{I}$

$= \dfrac{E \times T}{I} = \dfrac{(\text{kg-m}^2/\text{s}^2) \times \text{s}}{(\text{kg-m}^2)}$

$= \dfrac{1}{\text{s}} = \dfrac{1}{\text{time}} =$ frequency

Thus, dimensions of $\dfrac{h}{I}$ is same as that of frequency.

32 The dimensions of universal gravitational constant are **[CBSE AIPMT 2004, 1992]**

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

Ans. *(a)*

According to Newton's law of gravitation, the force of attraction between two masses m_1 and m_2 separated by a distance r is,

$F = \dfrac{G\, m_1 m_2}{r^2} \Rightarrow G = \dfrac{Fr^2}{m_1 m_2}$

Substituting the dimensions for the quantities on the right hand side, we obtain

Dimensions of $G = \dfrac{[MLT^{-2}][L^2]}{[M]^2}$

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

33 Planck's constant has the dimensions of **[CBSE AIPMT 2001]**

(a) linear momentum
(b) angular momentum
(c) energy
(d) power

Ans. *(b)*

$E = h\nu$

$\Rightarrow h = \text{Planck's constant} = \dfrac{\text{Energy } (E)}{\text{frequency } (\nu)}$

$\therefore [h] = \dfrac{E}{\nu} = \dfrac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$

(a) Linear momentum = Mass × velocity

or $\quad p = m \times v = [M][LT^{-1}] = [MLT^{-1}]$

(b) Angular momentum

= Moment of inertia × angular velocity

or $\quad L = I \times \omega = mr^2\omega \quad [\because I = mr^2]$

$\therefore \quad [L] = [M][L^2][T^{-1}] = [ML^2T^{-1}]$

(c) Energy $[E] = [ML^2T^{-2}]$

(d) Power = Force × velocity

or $\quad P = F \times v$

$\therefore \quad [P] = [MLT^{-2}][LT^{-1}] = [ML^2T^{-3}]$

Hence, option (b) is correct.

34 A pair of physical quantities having same dimensional formula is **[CBSE AIPMT 2000]**

(a) force and torque
(b) work and energy
(c) force and impulse
(d) linear momentum and angular momentum

Ans. *(b)*

(a) Force = Mass × acceleration

or $F = ma$

$= [M][LT^{-2}] = [MLT^{-2}]$

Torque = Moment of inertia × angular acceleration

or $\tau = I \times \alpha = [ML^2][T^{-2}] = [ML^2T^{-2}]$

(b) Work = Force × displacement

or $W = F \times d = [MLT^{-2}][L] = [ML^2T^{-2}]$

Energy $= \dfrac{1}{2} \times \text{mass} \times (\text{velocity})^2$

or $K = \dfrac{1}{2}mv^2 = [M][LT^{-1}]^2 = [ML^2T^{-2}]$

(c) Force as discussed above

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

Impulse = Force × time-interval

$\therefore \quad [I] = [MLT^{-2}][T] = [MLT^{-1}]$

(d) Linear momentum = Mass × velocity

or $\quad p = mv$

$\therefore \quad [p] = [M][LT^{-1}] = [MLT^{-1}]$

Angular momentum = Moment of inertia × angular velocity

or $\quad [L] = [I] \times [\omega]$

$\therefore \quad [L] = [ML^2][T^{-1}] = [ML^2T^{-1}]$

Hence, we observe that choice (b) is correct.

35 The dimensional formula for magnetic flux is **[CBSE AIPMT 1999]**

(a) $[ML^2T^{-2}A^{-1}]$ (b) $[ML^3T^{-2}A^{-2}]$
(c) $[M^0L^{-2}T^2A^{-2}]$ (d) $[ML^2T^{-1}A^2]$

Ans. *(a)*

Mathematically, magnetic flux

$\phi = BA \quad$ ...(i)

but magnetic force

$F = Bil$ or $B = \frac{F}{il}$

Putting the value of B in Eq. (i), we have

$$\phi = \frac{F}{il} A$$

Thus, dimensions of $\phi = \frac{[MLT^{-2}][L^2]}{[AL]}$

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

36 The force F on a sphere of radius r moving in a medium with velocity v is given by $F = 6\pi \eta r v$. The dimensions of η are **[CBSE AIPMT 1997]**

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

Ans. ***(d)***

Viscous force on a sphere of radius r is

$$F = 6\pi\eta r v \Rightarrow \eta = \frac{F}{6\pi r v}$$

$$[\eta] = \frac{[F]}{[r][v]} = \frac{[MLT^{-2}]}{[L][LT^{-1}]} = [ML^{-1}T^{-1}]$$

37 Which of the following will have the dimensions of time? **[CBSE AIPMT 1996]**

(a) LC (b) $\frac{R}{L}$ (c) $\frac{L}{R}$ (d) $\frac{C}{L}$

Ans. ***(c)***

$\frac{L}{R}$ is time constant of R-L circuit so, dimensions of $\frac{L}{R}$ is same as that of time.

Alternative

$$\frac{\text{Dimensions of } L}{\text{Dimensions of } R} = \frac{[ML^2T^{-2}A^{-2}]}{[ML^2T^{-3}A^{-2}]} = [T]$$

38 An equation is given as $\left(p + \frac{a}{V^2}\right) = b\frac{\theta}{V}$, where p = pressure, V = volume and θ = absolute temperature. If a and b are constants, then dimensions of a will be **[CBSE AIPMT 1996]**

(a) $[ML^5T^{-2}]$ (b) $[M^{-1}L^5T^2]$
(c) $[ML^{-5}T^{-1}]$ (d) $[ML^5T]$

Ans. ***(a)***

From principle of homogeneity of dimensions.

Dimensions of p = dimensions of $\frac{a}{V^2}$

$$p = \frac{a}{V^2} \Rightarrow a = pV^2$$

$$= [ML^{-1}T^{-2}][L^3]^2 = [ML^5T^{-2}]$$

39 Which of the following is a dimensional constant? **[CBSE AIPMT 1995]**

(a) Refractive index
(b) Poisson's ratio
(c) Relative density
(d) Gravitational constant

Ans. ***(d)***

A quantity which has dimensions and also has a constant value is called dimensional constant.
Here, gravitational constant (G) is a dimensional constant.

40 Turpentine oil is flowing through a tube of length l and radius r. The pressure difference between the two ends of the tube is p. The viscosity of oil is given by

$$\eta = \frac{p(r^2 - x^2)}{4vl}$$

where, v is the velocity of oil at distance x from the axis of the tube. The dimensions of η are **[CBSE AIPMT 1993]**

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

Ans. ***(d)***

Pressure

$$(p) = \frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

Velocity, $v = [LT^{-1}]$

From principle of homogeneity, the dimensions of r^2 and x^2 are same.

So, the dimensions of viscosity,

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

41 The time dependence of physical quantity p is given by $p = p_0 \exp(-\alpha t^2)$, where α is a constant and t is the time. The constant α **[CBSE AIPMT 1992]**

(a) is dimensionless
(b) has dimensions $[T^{-2}]$
(c) has dimensions $[T^2]$
(d) has dimensions of p

Ans. ***(b)***

$$p = p_0 \exp(-\alpha t^2)$$

As powers of exponential quantity is dimensionless, so αt^2 is dimensionless.

or αt^2 = dimensionless $= [M^0L^0T^0]$

$\therefore$ $\alpha = \frac{1}{t^2} = \frac{1}{[T^2]} = [T^{-2}]$

42 If p represents radiation pressure, c represents speed of light and S represents radiation energy striking unit area per sec. The non-zero integers x, y, z such that $p^x S^y c^z$ is dimensionless are **[CBSE AIPMT 1992]**

(a) $x = 1, y = 1, z = 1$
(b) $x = -1, y = 1, z = 1$
(c) $x = 1, y = -1, z = 1$
(d) $x = 1, y = 1, z = -1$

Ans. ***(c)***

Radiation pressure, $p = [ML^{-1}T^{-2}]$

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

Energy striking unit area per second

$$S = \frac{[ML^2T^{-2}]}{[L^2T]} = [MT^{-3}]$$

Now, $p^x S^y c^z$ is dimensionless.

$\therefore$ $[M^0L^0T^0] = p^x S^y c^z$

or $[M^0L^0T^0] = [M^1L^{-1}T^{-2}]^x [M^1T^{-3}]^y [L^1T^{-1}]^z$

or $[M^0L^0T^0] = [M]^{x+y} [L]^{-x+z} [T]^{-2x-3y-z}$

From principle of homogeneity of dimensions

$x + y = 0$ ...(i)

$-x + z = 0$ ...(ii)

$-2x - 3y - z = 0$ ...(iii)

Solving Eqs. (i), (ii) and (iii), we get

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

43 The dimensional formula for permeability of free space, μ_0 is **[CBSE AIPMT 1991]**

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

Ans. ***(a)***

From Biot-Savart law

$$dB = \frac{\mu_0}{4\pi}\frac{Idl \sin\theta}{r^2}$$

Idl = current element

r = displacement vector

$$\mu_0 = \frac{4\pi r^2 (dB)}{Idl \sin\theta} = \frac{[L^2][MT^{-2}A^{-1}]}{[A][L]}$$

$$= [MLT^{-2}A^{-2}]$$

44 The frequency of vibration f of a mass m suspended from a spring of spring constant k is given by a relation of the type $f = Cm^x k^y$, where C is a dimensionless constant. The values of x and y are **[CBSE AIPMT 1990]**

(a) $x = \frac{1}{2}, y = \frac{1}{2}$ (b) $x = -\frac{1}{2}, y = -\frac{1}{2}$
(c) $x = \frac{1}{2}, y = -\frac{1}{2}$ (d) $x = -\frac{1}{2}, y = \frac{1}{2}$

Ans. *(d)*

As $f = Cm^x k^y$

$\therefore$ (Dimension of f) $= C$ (dimension of m)^x $\times$(dimensions of k)^y

$$[T^{-1}] = C\ [M]^x\ [MT^{-2}]^y \quad ...(i)$$

$$\left(\text{where, } k = \frac{\text{force}}{\text{length}}\right)$$

Applying the principle of homogeneity of dimensions, we get

$$x + y = 0,\ -2y = -1 \text{ or } y = \frac{1}{2}$$

$$\therefore \quad x = -\frac{1}{2}$$

45 According to Newton, the viscous force acting between liquid layers of area A and velocity gradient $\frac{\Delta v}{\Delta z}$ is given by $F = -\eta A \frac{dv}{dz}$, where η is constant called **[CBSE AIPMT 1990]**

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

(b) $[M^0L^0T^0]$

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

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

Ans. *(d)*

As $F = -\eta A \frac{dv}{dz} \Rightarrow \eta = -\frac{F}{A\left(\frac{dv}{dz}\right)}$

As $F = [MLT^{-2}]$, $A = [L^2]$

$dv = [LT^{-1}]$, $dz = [L]$

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

46 The dimensional formula of pressure is **[CBSE AIPMT 1990]**

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

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

Ans. *(c)*

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{F}{A} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

47 The dimensional formula of torque is **[CBSE AIPMT 1989]**

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

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

Ans. *(a)*

Torque $\tau = \mathbf{r} \times \mathbf{F}$

Dimensions of τ = dimension of $\mathbf{r}$ $\times$ dimension of $\mathbf{F}$

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

48 If $x = at + bt^2$, where x is the distance travelled by the body in kilometer while t is the time in second, then the unit of b is **[CBSE AIPMT 1989]**

(a) km/s (b) km-s (c) km/s^2 (d) km-s^2

Ans. *(c)*

Ans.As $x = at + bt^2$

According to the concept of dimensional analysis and principle of homogeneity

$\therefore$ unit of x = unit of bt^2

$$\therefore \quad \text{unit of } b = \frac{\text{unit of } x}{\text{unit of } t^2} = \text{km /s}^2$$

49 Dimensional formula of self-inductance is **[CBSE AIPMT 1989]**

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

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

Ans. *(c)*

As we know that emf induced in the inductors is given by

$$e = L\frac{di}{dt} \quad \Rightarrow L = \frac{edt}{di} = \frac{W}{q} \cdot \frac{dt}{di}$$

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

50 Of the following quantities, which one has dimensions different from the remaining three? **[CBSE AIPMT 1989]**

(a) Energy per unit volume

(b) Force per unit area

(c) Product of voltage and charge per unit volume

(d) Angular momentum

Ans. *(d)*

Dimensions of energy per unit volume

$$= \frac{\text{Dimensions of energy}}{\text{Dimensions of volume}}$$

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

Dimensions of force per unit area

$$= \frac{\text{Dimensions of force}}{\text{Dimensions of area}} = \frac{[MLT^{-2}]}{[L^2]}$$

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

Voltage $\times$ Charge/ Volume

$$= \frac{\left(\frac{W}{q}\right) \times (it)}{l^3} = \frac{(W)}{(l^3)} = \frac{[ML^2T^{-2}]}{[L^3]}$$

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

Angular momentum

$$= (r)(p) = (r)(mv) = [L][M][LT^{-1}]$$

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

So, dimensions of angular momentum is different from other three.

51 The dimensional formula for angular momentum is **[CBSE AIPMT 1988]**

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

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

(c) $[MLT^{-1}]$

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

Ans. *(b)*

Angular momentum

$$L = \mathbf{r} \times \mathbf{p} = \mathbf{r} \times mv$$

$\therefore$ Dimensional formula for angular momentum

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

52 If C and R denote capacitance and resistance respectively, then the dimensional formula of CR is **[CBSE AIPMT 1988]**

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

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

(d) Not expressible in terms of $[MLT]$

Ans. *(a)*

$$\because C = \frac{q}{V} = \frac{q}{\frac{W}{q}} = \frac{q^2}{W} = \frac{(it)^2}{F \cdot x} = \frac{[AT]^2}{[ML^2T^{-2}]}$$

$$= [M^{-1}L^{-2}T^4A^2] \quad \text{and} \quad R = \frac{V}{i} = \frac{W}{qi}$$

$$= \frac{F \cdot x}{i^2 t} = \frac{[ML^2T^{-2}]}{[AT][A]} = [ML^2T^{-3}A^{-2}]$$

$\therefore$ Dimensional formula of CR

$$= [M^{-1}L^{-2}T^4A^2][ML^2T^{-3}A^{-2}] = [M^0L^0T]$$