Chapter 1. Units and Measurement

1. 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 the universal constant of gravitation and e is charge]

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

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

(NEET 2017)

2. 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 ?

(a) $\frac{\sqrt{hG}}{c^{3/2}}$ (b) $\frac{\sqrt{hG}}{c^{5/2}}$ (c) $\sqrt{\frac{hc}{G}}$ (d) $\sqrt{\frac{Gc}{h^{3/2}}}$

(NEET-II 2016)

3. 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

(a) $-1, -1, -1$ (b) 1, 1, 1
(c) $1, -1, -1$ (d) $-1, -1, 1$ *(2015)*

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

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

(2015 Cancelled)

5. If force (F), velocity (V) and time (T) are taken as fundamental units, then the dimensions of mass are

(a) $[FVT^{-1}]$ (b) $[FVT^{-2}]$
(c) $[FV^{-1}T^{-1}]$ (d) $[FV^{-1}T]$ *(2014)*

6. 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) 7% (b) 4% (c) 14% (d) 10%

(NEET 2013)

7. The pair of quantities having same dimensions is
(a) Impulse and Surface Tension
(b) Angular momentum and Work
(c) Work and Torque
(d) Young's modulus and Energy

(Karnataka NEET 2013)

8. The damping force on an oscillator is directly proportional to the velocity. The units of the constant of proportionality are

(a) kg m s^{-1} (b) kg m s^{-2}
(c) kg s^{-1} (d) kg s *(2012)*

9. The dimensions of $(\mu_0\varepsilon_0)^{-1/2}$ are

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

(Mains 2012, 2011)

10. The density of a material in CGS system of units is 4 g cm^{-3}. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, the value of density of material will be

(a) 0.04 (b) 0.4 (c) 40 (d) 400

(Mains 2011)

11. The dimension of $\frac{1}{2}\varepsilon_0E^2$, where ε_0 is permittivity of free space and E is electric field, is

(a) ML^2T^{-2} (b) $ML^{-1}T^{-2}$
(c) ML^2T^{-1} (d) MLT^{-1} *(2010)*

12. A student measures the distance traversed in free fall of a body, initially at rest, in a given time. He uses this data to estimate g, the acceleration due to gravity. If the maximum percentage errors in measurement of the distance and the time are e_1 and e_2 respectively, the percentage error in the estimation of g is

(a) $e_2 - e_1$ (b) $e_1 + 2e_2$
(c) $e_1 + e_2$ (d) $e_1 - 2e_2$

(Mains 2010)

13. If the dimensions of a physical quantity are given by $M^aL^bT^c$, then the physical quantity will be
(a) velocity if $a = 1, b = 0, c = -1$
(b) acceleration if $a = 1, b = 1, c = -2$
(c) force if $a = 0, b = -1, c = -2$
(d) pressure if $a = 1, b = -1, c = -2$ *(2009)*

14. 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
(a) 8% (b) 2% (c) 4% (d) 6% *(2008)*

15. Which two of the following five physical parameters have the same dimensions ?
1. energy density 2. refractive index
3. dielectric constant 4. Young's modulus
5. magnetic field
(a) 1 and 4 (b) 1 and 5
(c) 2 and 4 (d) 3 and 5 *(2008)*

16. 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
(a) $[ML^2T^{-2}]$ (b) $[ML^2T^{-1}I^{-1}]$
(c) $[ML^2T^{-3}I^{-2}]$ (d) $[ML^2T^{-3}I^{-1}]$. *(2007)*

17. The velocity v of a particle at time t is given by $v = at + \frac{b}{t+c}$, where a, b and c are constants. The dimensions of a, b and c are
(a) [L], [LT] and $[LT^{-2}]$ (b) $[LT^{-2}]$, [L] and [T]
(c) $[L^2]$, [T] and $[LT^{-2}]$ (d) $[LT^{-2}]$, [LT] and [L]. *(2006)*

18. The ratio of the dimensions of Planck's constant and that of moment of inertia is the dimensions of
(a) time (b) frequency
(c) angular momentum (d) velocity. *(2005)*

19. The dimensions of universal gravitational constant are
(a) $[M^{-1}L^3T^{-2}]$ (b) $[ML^2T^{-1}]$
(c) $[M^{-2}L^3T^{-2}]$ (d) $[M^{-2}L^2T^{-1}]$ *(2004, 1992)*

20. The unit of permittivity of free space, ε_0, is
(a) coulomb/newton-metre
(b) newton-metre²/coulomb²
(c) coulomb²/newton-metre²
(d) coulomb²/(newton-metre)² *(2004)*

21. The dimensions of Planck's constant equals to that of
(a) energy (b) momentum
(c) angular momentum (d) power. *(2001)*

22. Which pair do not have equal dimensions ?
(a) Energy and torque (b) Force and impulse
(c) Angular momentum and Planck constant
(d) Elastic modulus and pressure. *(2000)*

23. The dimensional formula of magnetic flux is
(a) $[M^0L^{-2}T^{-2}A^{-2}]$ (b) $ML^0T^{-2}A^{-2}]$
(c) $[ML^2T^{-2}A^{-1}]$ (d) $[ML^2T^{-1}A^3]$ *(1999)*

24. An equation is given here $\left(P + \frac{a}{V^2}\right) = b\frac{\theta}{V}$ where P = Pressure, V = Volume and θ = Absolute temperature. If a and b are constants, the dimensions of a will be
(a) $[ML^{-5}T^{-1}]$ (b) $[ML^5T^1]$
(c) $[ML^5T^{-2}]$ (d) $[M^{-1}L^5T^2]$. *(1996)*

25. 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 lengths are 3% and 2% respectively, the maximum error in the measurement of density would be
(a) 12% (b) 14% (c) 7% (d) 9%. *(1996)*

26. The dimensions of impulse are equal to that of
(a) pressure (b) linear momentum
(c) force (d) angular momentum. *(1996)*

27. Which of the following dimensions will be the same as that of time?
(a) $\frac{L}{R}$ (b) $\frac{C}{L}$ (c) LC (d) $\frac{R}{L}$. *(1996)*

28. Which of the following is a dimensional constant?
(a) Relative density (b) Gravitational constant
(c) Refractive index (d) Poisson ratio. *(1995)*

29. The dimensions of RC is
(a) square of time (b) square of inverse time
(c) time (d) inverse time. *(1995)*

30. Percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in the estimate of kinetic energy obtained by measuring mass and speed will be
(a) 8% (b) 2% (c) 12% (d) 10%. *(1995)*

31. Which of the following has the dimensions of pressure?
(a) $[MLT^{-2}]$ (b) $[ML^{-1}T^{-2}]$
(c) $[ML^{-2}T^{-2}]$ (d) $[M^{-1}L^{-1}]$. *(1994, 90)*

32. 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 a distance x from the axis of the tube. The dimensions of h are
(a) $[M^0L^0T^0]$ (b) $[MLT^{-1}]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$ *(1993)*

33. The time dependence of a physical quantity p is given by $p = p_0 \exp(-at^2)$, where a is a constant and t is the time. The constant a
(a) is dimensionless
(b) has dimensions $[T^{-2}]$
(c) has dimensions $[T^2]$
(d) has dimensions of p *(1993)*

34. P represents radiation pressure, c represents speed of light and S represents radiation energy striking per unit area per sec. The non zero integers x, y, z such that $P^x S^y c^z$ is dimensionless are
(a) $x = 1, y = 1, z = 1$ (b) $x = -1, y = 1, z = 1$
(c) $x = 1, y = -1, z = 1$ (d) $x = 1, y = 1, z = -1$ *(1992)*

35. A certain body weighs 22.42 g and has a measured volume of 4.7cc. The possible error in the measurement of mass and volume are 0.01 g and 0.1 cc. Then maximum error in the densiy will be
(a) 22% (b) 2% (c) 0.2% (d) 0.02%. *(1991)*

36. The dimensional formula of permeability of free space m_0 is
(a) $[MLT^{-2}A^{-2}]$ (b) $[M^0L^1T]$
(c) $[M^0L^2T^{-1}A^2]$ (d) none of these. *(1991)*

37. The frequency of vibration f of a mass m suspended from a spring of spring constant k is given by a relation $f = am^xk^y$, where a is a dimensionless constant. The values of x and y are
(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) $x = -\frac{1}{2}, y = \frac{1}{2}$. *(1990)*

38. According to Newton, the viscous force acting between liquid layers of area A and velocity gradient $\Delta v/\Delta Z$ is given by $F = -\eta A \frac{\Delta v}{\Delta Z}$, where h is constant called coefficient of viscosity. The dimensional formula of h is
(a) $[ML^{-2}T^{-2}]$ (b) $[M^0L^0T^0]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$. *(1990)*

39. If $x = at + bt^2$, where x is the distance travelled by the body in kilometers while t is the time in seconds, then the units of b is
(a) km/s (b) km s (c) km/s² (d) km s². *(1989)*

40. Of the following quantities, which one has dimensions different from the remaining three ?
(a) Energy per unit volume
(b) Force per unit area
(c) Product of voltage and charge per unit volume
(d) Angular momentum. *(1989)*

41. Dimensional formula of self inductance is
(a) $[MLT^{-2}A^{-2}]$ (b) $[ML^2T^{-1}A^{-2}]$
(c) $[ML^2T^{-2}A^{-2}]$ (d) $[ML^2T^{-2}A^{-1}]$. *(1989)*

42. The dimensional formula of torque is
(a) $[ML^2T^{-2}]$ (b) $[MLT^{-2}]$
(c) $[ML^{-1}T^{-2}]$ (d) $[ML^{-2}T^{-2}]$. *(1989)*

43. If C and R denote capacitance and resistance, the dimensional formula of CR is
(a) $[M^0L^0T^1]$ (b) $[M^0L^0T^0]$
(c) $[M^0L^0T^{-1}]$
(d) not expressible in terms of MLT. *(1988)*

44. The dimensional formula of angular momentum is
(a) $[ML^2T^{-2}]$ (b) $[ML^{-2}T^{-1}]$
(c) $[MLT^{-1}]$ (d) $[ML^2T^{-1}]$. *(1988)*

Answer Key

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

EXPLANATIONS

1. **(d)** : Dimensions of

$$\frac{e^2}{4\pi\varepsilon_o} = [F \times d^2] = [ML^3T^{-2}]$$

Dimensions of $G = [M^{-1}L^3T^{-2}]$,
Dimensions of $c = [LT^{-1}]$

$$l \propto \left(\frac{e^2}{4\pi\varepsilon_o}\right)^p G^q c^r$$

$\therefore [L^1] = [ML^3T^{-2}]^p [M^{-1}L^3T^{-2}]^q [LT^{-1}]^r$

On comparing both sides and solving, we get

$$p = \frac{1}{2}, \quad q = \frac{1}{2} \text{ and } r = -2$$

$$\therefore \ l = \frac{1}{c^2}\left[\frac{Ge^2}{4\pi\varepsilon_o}\right]^{1/2}$$

2. **(a)** : According to question,

$l \propto h^p c^q G^r$

$l = k h^p c^q G^r$ ...(i)

Writting dimensions of physical quantities on both sides,

$[M^0LT^0] = [ML^2T^{-1}]^p [LT^{-1}]^q [M^{-1}L^3T^{-2}]^r$

Applying the principle of homogeneity of dimensions, we get

$p - r = 0$ ...(ii)

$2p + q + 3r = 1$ ...(iii)

$-p - q - 2r = 0$ ...(iv)

Solving eqns. (ii), (iii) and (iv), we get

$$p = r = \frac{1}{2}, \ q = -\frac{3}{2}$$

From eqn. (i) $l = \dfrac{\sqrt{hG}}{c^{3/2}}$

3. **(c)** : $[v_c] = [\eta^x \rho^y r^z]$ (given) ... (i)

Writing the dimensions of various quantities in eqn. (i), we get

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

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

Applying the principle of homogeneity of dimensions, we get

$x + y = 0; \ -x - 3y + z = 1; \ -x = -1$

On solving, we get

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

4. **(a)** : Let $S = kE^aV^bT^c$

where k is a dimensionless constant.

Writing the dimensions on both sides, we get

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

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

Applying principle of homogeneity of dimensions, we get, $a = 1$ ...(i)

$2a + b = 0$ ...(ii)

$-2a - b + c = -2$ ...(iii)

Adding (ii) and (iii), we get

$c = -2$

From (ii), $b = -2a = -2$

$\therefore \ S = kEV^{-2}T^{-2}$ or $[S] = [EV^{-2}T^{-2}]$

5. **(d)** : Let mass $m \propto F^aV^bT^c$

or $m = kF^aV^bT^c$ ...(i)

where k is a dimensionless constant and a, b and c are the exponents.

Writing dimensions on both sides, we get

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

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

Applying the principle of homogeneity of dimensions, we get

$a = 1$ ... (ii)

$a + b = 0$ ... (iii)

$-2a - b + c = 0$ ... (iv)

Solving eqns. (ii), (iii) and (iv), we get

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

From eqn. (i), $[m] = [FV^{-1}T]$

6. **(c)** : As $P = \dfrac{a^3b^2}{cd}$

% error in P is

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

$= [3 \times 1\% + 2 \times 2\% + 3\% + 4\%] = 14\%$

7. **(c)** : Impulse = Force × time

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

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

Angular momentum

= Moment of inertia × angular velocity

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

Work = Force × distance $= [MLT^{-2}][L] = [ML^2T^{-2}]$

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

Torque = Force × distance $= [MLT^{-2}][L] = [ML^2T^{-2}]$

Young's modulus

$$= \frac{\text{Force / Area}}{\text{Change in length / original length}}$$

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

Hence, among the given pair of physical quantities work and torque have the same dimensions $[ML^2T^{-2}]$.

8. (c) : Damping force, $F \propto v$ or $F = kv$

where k is the constant of proportionality

$$\therefore \quad k = \frac{F}{v} = \frac{N}{m\,s^{-1}} = \frac{kg\,m\,s^{-2}}{m\,s^{-1}} = kg\,s^{-1}$$

9. (c) : The speed of the light in vacuum is

$$c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = (\mu_0\varepsilon_0)^{-1/2}$$

$$\therefore \quad [(\mu_0\varepsilon_0)^{-1/2}] = [c] = [LT^{-1}]$$

10. (c) : As $n_1u_1 = n_2u_2$

$$4\frac{g}{cm^3} = n_2\frac{100g}{(10\ cm)^3} \Rightarrow n_2 = 40$$

11. (b) : Energy density of an electric field E is

$$u_E = \frac{1}{2}\varepsilon_0 E^2$$

where ε_0 is permittivity of free space

$$u_E = \frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} = ML^{-1}T^{-2}$$

Hence, the dimension of $\frac{1}{2}\varepsilon_0 E^2$ is $ML^{-1}T^{-2}$

12. (b) : From the relation

$$h = ut + \frac{1}{2}gt^2$$

$$h = \frac{1}{2}gt^2 \Rightarrow g = \frac{2h}{t^2} \quad (\because \text{ body initially at rest})$$

Taking natural logarithm on both sides, we get

$$\ln g = \ln h - 2\ln t$$

Differentiating, $\frac{\Delta g}{g} = \frac{\Delta h}{h} - 2\frac{\Delta t}{t}$

For maximum permissible error,

$$\text{or} \quad \left(\frac{\Delta g}{g}\times 100\right)_{max} = \left(\frac{\Delta h}{h}\times 100\right) + 2\times\left(\frac{\Delta t}{t}\times 100\right)$$

According to problem

$$\frac{\Delta h}{h}\times 100 = e_1 \text{ and } \frac{\Delta t}{t}\times 100 = e_2$$

Therefore, $\left(\frac{\Delta g}{g}\times 100\right)_{max} = e_1 + 2e_2$

13. (d) : Pressure, $P = \frac{\text{force}}{\text{area}} = \frac{\text{mass} \times \text{acceleration}}{\text{area}}$

$$\therefore \quad [P] = \frac{M^1LT^{-2}}{L^2} = [M^1L^{-1}T^{-2}] = M^aL^bT^c.$$

$\therefore \quad a = 1, b = -1, c = -2.$

14. (d) : $V = \frac{4}{3}\pi R^3$; $\ln V = \ln\left(\frac{4}{3}\pi\right) + \ln R^3$

Differentiating, $\frac{dV}{V} = 3\frac{dR}{R}$

Error in the determination of the volume

$$= 3 \times 2\% = 6\%$$

15. (a) :

$$[\text{Energy density}] = \left[\frac{\text{Work done}}{\text{Volume}}\right] = \frac{MLT^{-2}\cdot L}{L^3} = [ML^{-1}T^{-2}]$$

$$[\text{Young's modulus}] = [Y] = \left[\frac{\text{Force}}{\text{Area}}\right]\times\frac{[l]}{[\Delta l]} = \frac{MLT^{-2}}{L^2}\cdot\frac{L}{L} = [ML^{-1}T^{-2}]$$

The dimensions of 1 and 4 are the same.

16. (c) : According to Ohm's law,

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

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

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

17. (b) : $v = at + \frac{b}{t+c}$

As c is added to t, $\therefore \quad [c] = [T]$

$$[at] = [LT^{-1}] \quad \text{or,} \quad [a] = \frac{[LT^{-1}]}{[T]} = [LT^{-2}]$$

$$\frac{[b]}{[T]} = [LT^{-1}] \quad \therefore [b] = [L].$$

18. (b) : $\frac{h}{I} = \frac{E\lambda}{c\times I} = \frac{[ML^2T^{-2}][L]}{[LT^{-1}]\times[ML^2]}$

$$\frac{h}{I} = [T^{-1}] = \text{frequency.}$$

19. (a) : Gravitational constant G

$$= \frac{\text{force} \times (\text{distance})^2}{\text{mass} \times \text{mass}}$$

$$\therefore \quad \text{Dimensions of } G = \frac{[MLT^{-2}][L^2]}{[M][M]} = [M^{-1}L^3T^{-2}]$$

20. (c) : Force between two charges

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} \Rightarrow \varepsilon_0 = \frac{1}{4\pi}\frac{q^2}{Fr^2} = C^2/N\text{-}m^2$$

21. **(c) :** Dimensions of Planck constant

$$h = \frac{\text{Energy}}{\text{Frequency}} = \frac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$$

Dimensions of angular momentum L

= Moment of inertia I × Angular velocity ω

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

22. **(b) :** Dimensions of force = $[MLT^{-2}]$

Dimensions of impulse = $[MLT^{-1}]$.

23. **(c) :** Magnetic flux, $\phi = BA = \left(\frac{F}{Il}\right)A$

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

24. **(c) :** Equation $\left(P + \frac{a}{V^2}\right) = b\,\frac{\theta}{V}$. Since $\frac{a}{V^2}$ is added to the pressure, therefore dimensions of $\frac{a}{V^2}$ and pressure (P) will be the same. And dimensions of $\frac{a}{V^2} = \frac{a}{[L^3]^2} = [ML^{-1}T^{-2}]$

or $a = [ML^5T^{-2}]$.

25. **(d) :** Maximum error in mass $\left(\frac{\Delta m}{m}\right) = 3\ \% = \frac{3}{100}$ and maximum error in length $\left(\frac{\Delta l}{l}\right) = 2\,\% = \frac{2}{100}$

Maximum error in the measurement of density,

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + \left(3\times\frac{\Delta l}{l}\right) = \frac{3}{100} + \left(3\times\frac{2}{100}\right) = \frac{3}{100} + \frac{6}{100}$$

$$= \frac{9}{100} = 9\%.$$

26. **(b) :** Impulse = Force × Time.

Therefore dimensional formula of impulse = Dimensional formula of force × Dimensional formula of time = $[MLT^{-2}]$ $[T]$ = $[MLT^{-1}]$ and dimensional formula of linear momentum $[p] = MLT^{-1}$.

27. **(a)**

28. **(b) :** Relative density, refractive index and Poisson ratio all the three are ratios, therefore they are dimensionless constants.

29. **(c) :** Units of RC = ohm × ohm^{-1} × second = second. Therefore dimensions of RC = time.

30. **(a) :** Percentage error in mass = 2% = $\frac{2}{100}$ and percentage error in speed = 3 % = $\frac{3}{100}$.

$$K.E. = \frac{1}{2}mv^2$$

Therefore the error in measurement of kinetic energy

$$\frac{\Delta\,K.E.}{K.E.} = \frac{\Delta m}{m} + 2\times\frac{\Delta v}{v} = \frac{2}{100} + 2\times\frac{3}{100} = \frac{8}{100} = 8\,\%$$

31. **(b) :** Pressure = $\frac{\text{Force}}{\text{Area}}$. Therefore dimensions of pressure = $\frac{[MLT^{-2}]}{[L^2]} = ML^{-1}T^{-2}$.

32. **(d) :** Dimensions of $P = [ML^{-1}T^{-2}]$

Dimensions of $r = [L]$

Dimensions of $v = [LT^{-1}]$

Dimensions of $l = [L]$

$\therefore$ Dimensions of $\eta = \frac{[P][r^2 - x^2]}{[4vl]} = \frac{[ML^{-1}T^{-2}][L^2]}{[LT^{-1}][L]}$

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

33. **(b) :** Given $p = p_0 e^{-\alpha t^2}$

αt^2 is a dimensionless

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

34. **(c) :** Let $k = P^x S^y c^z$ .....(i)

k is a dimensionless

Dimensions of $k = [M^0L^0T^0]$

$\therefore$ Dimensions of $P = \frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

Dimensions of $S = \frac{\text{Energy}}{\text{Area}\times\text{time}} = \frac{[ML^2T^{-2}]}{[L^2][T]} = [MT^{-3}]$

Dimensions of $c = [LT^{-1}]$

Substituting these dimensions in eqn (i), we get

$[M^0L^0T^0] = [ML^{-1}T^{-2}]^x [MT^{-3}]^y [LT^{-1}]^z$.

Applying the principle of homogeneity of dimensions, we get

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

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

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

Solving (ii), (iii) and (iv), we get

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

35. **(b) :** Density $\rho = \frac{\text{mass } m}{\text{volume } V}$ .....(i)

Take logarithm to take base e on the both sides of eqn (i), we get

$\ln\rho = \ln m - \ln V$ .....(ii)

Differentiate eqn (ii), on both sides, we get

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

Errors are always added, Error in the density ρ will be

$$= \left[\frac{\Delta m}{m} + \frac{\Delta V}{V}\right]\times 100\%$$

$$= \left[\frac{0.01}{22.42} + \frac{0.1}{4.7}\right]\times 100\% = 2\ \%$$

36. **(a) :** Permeability of free space

$$\mu_0 = \frac{2\pi \times \text{force} \times \text{distance}}{\text{current} \times \text{current} \times \text{length}}$$

Dimensional formula of $\mu_0 = \frac{[MLT^{-2}][L]}{[A][A][L]}$
$= [MLT^{-2}A^{-2}]$

37. **(d) :** $f = am^x k^y$ .....(i)

Dimensions of frequency $f = [M^0L^0T^{-1}]$
Dimensions of constant $a = [M^0L^0T^0]$
Dimensions of mass $m = [M]$
Dimensions of spring constant $k = [MT^{-2}]$
Putting these value in equation (i), we get

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

Applying principle of homogeneity of dimensions, we get

$$x + y = 0 \quad \text{.....(ii)}$$
$$-2y = -1 \quad \text{.....(iii)}$$

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

38. **(d) :** Dimensions of force $F = [MLT^{-2}]$

Dimensions of velocity gradient $\frac{\Delta v}{\Delta Z} = \frac{[LT^{-1}]}{[L]}$
$= [T^{-1}]$

Dimensions of area $A = [L^2]$

Given $F = -\eta A \frac{\Delta v}{\Delta Z}$

Dimensional formula for coefficient of viscocity

$$\eta = \frac{F}{(A)\left(\frac{\Delta v}{\Delta Z}\right)} = \frac{[MLT^{-2}]}{[L^2][T^{-1}]} = [ML^{-1}T^{-1}]$$

39. **(c) :** Units of $b = \frac{x}{t^2} = \frac{\text{km}}{\text{s}^2}$

40. **(d) :** Dimensions of energy $E = [ML^2T^{-2}]$
Dimensions of volume $v = [L^3]$
Dimensions of force $F = [MLT^{-2}]$
Dimensions of area $A = [L^2]$
Dimensions of voltage $V = [ML^2T^{-3}A^{-1}]$
Dimensions of charge $q = [AT]$
Dimensions of angular momentum $L = [ML^2T^{-1}]$

$\therefore$ Dimensions of $\frac{E}{v} = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

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

Dimensions of $\frac{Vq}{v} = \frac{[ML^2T^{-3}A^{-1}][AT]}{[L^3]} = [ML^{-1}T^{-2}]$

Dimensions of angular momentum is $[ML^2T^{-1}]$ while other three has dimensions $[ML^{-1}T^{-2}]$

41. **(c) :** Induced emf $|\varepsilon| = L\frac{dI}{dt}$

where L is the self inductance and $\frac{dI}{dt}$ is the rate of change of current.

$\therefore$ Dimensional formula of

$$L = \frac{|\varepsilon|}{\frac{dI}{dt}} = \frac{[ML^2T^{-3}A^{-1}]}{[AT^{-1}]} = [ML^2A^{-2}T^{-2}]$$

42. **(a) :** Torque (τ) = Force × distance
Dimensional formula for $(\tau) = [MLT^{-2}][L] = [ML^2T^{-2}]$

43. **(a) :** Capacitance $C = \frac{\text{charge}}{\text{Potential difference}}$

Dimensions of $C = \frac{[AT]}{[ML^2T^{-3}A^{-1}]} = [M^{-1}L^{-2}T^4A^2]$

Resistance $R = \frac{\text{Potential difference}}{\text{current}}$

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

Dimensional formula of CR

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

As the (CR) has dimensions of time and so is called time constant of CR circuit.

44. **(d) :** Angular momentum L
= Moment of inertia I × Angular velocity ω.

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