CHAPTER 2

Units and Measurements

2.2 The International System of Units

1. The unit of thermal conductivity is
(a) $W\,m^{-1}\,K^{-1}$ (b) $J\,m\,K^{-1}$
(c) $J\,m^{-1}\,K^{-1}$ (d) $W\,m\,K^{-1}$ *(NEET 2019)*

2. 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)*

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

2.6 Accuracy, Precision of Instruments and Errors in Measurement

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
(a) 0.01 mm (b) 0.25 mm
(c) 0.5 mm (d) 1.0 mm *(NEET 2020)*

5. 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 X, where $X = \dfrac{A^2 B^{1/2}}{C^{1/3} D^3}$, will be
(a) 10% (b) (3/13)%
(c) 16% (d) −10% *(NEET 2019)*

6. The main scale of a vernier callipers 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
(a) $\dfrac{1}{(n+1)(n-1)}$ cm (b) $\dfrac{1}{n}$ cm
(c) $\dfrac{1}{n^2}$ cm (d) $\dfrac{1}{n(n+1)}$ cm
(Odisha NEET 2019)

7. 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
(a) 0.521 cm (b) 0.525 cm
(c) 0.053 cm (d) 0.529 cm *(NEET 2018)*

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 $P = \dfrac{a^3 b^2}{cd}$. % error in P is
(a) 7% (b) 4% (c) 14% (d) 10%
(NEET 2013)

9. 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)*

10. 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)*

11. 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)*

12. 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)*

13. 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 density will be
(a) 22% (b) 2%
(c) 0.2% (d) 0.02%. *(1991)*

2.7 Significant Figures

14. Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m?
(a) 9.9801 m (b) 9.98 m
(c) 9.980 m (d) 9.9 m *(NEET 2020)*

2.8 Dimensions of Physical Quantities

15. Dimensions of stress are
(a) $[MLT^{-2}]$ (b) $[ML^2T^{-2}]$
(c) $[ML^0T^{-2}]$ (d) $[ML^{-1}T^{-2}]$ *(NEET 2020)*

16. 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)

17. 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)

18. The dimension of $\frac{1}{2}\varepsilon_0 E^2$, 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)*

19. 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)*

20. 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)*

21. 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)*

22. 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)*

23. 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)*

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

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

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

29. 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, 1990)*

30. 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)*

2.9 Dimensional Formulae and Dimensional Equations

31. 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)*

32. The dimensional formula of permeability of free space μ_0 is

(a) $[MLT^{-2}A^{-2}]$ (b) $[M^0L^1T]$
(c) $[M^0L^2T^{-1}A^2]$ (d) none of these. *(1991)*

33. 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 η is constant called coefficient of viscosity. The dimensional formula of η is
(a) $[ML^{-2}T^{-2}]$ (b) $[M^0L^0T^0]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$. *(1990)*

34. 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)*

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

36. 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)*

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

2.10 Dimensional Analysis and its Applications

38. 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) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$

(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)

39. 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)*

40. 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)*

41. 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)*

42. 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)*

43. 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)*

44. 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)*

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

46. 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 η are
(a) $[M^0L^0T^0]$ (b) $[MLT^{-1}]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$ *(1993)*

47. 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)*

48. 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)*

49. The frequency of vibration f of a mass m suspended from a spring of spring constant k is given by a relation $f = am^x k^y$, 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)*

50. 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/s^2 (d) km s^2 *(1989)*

ANSWER KEY

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

Hints & Explanations

1. **(a) :** $K = \frac{Qx}{A(T_1 - T_2)t}$, where Q is the amount of heat flow, x is the thickness of the slab, A is the area of cross-section, and t is the time taken.

$$K = \frac{\text{J m}}{\text{m}^2\text{ K s}} = \text{W}\frac{1}{\text{m}}\frac{1}{\text{K}} = \text{W m}^{-1}\text{ K}^{-1}$$

2. **(c) :** Damping force, $F \propto v$ or $F = kv$ where k is the constant of proportionality

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

3. **(c) :** Force between two charges

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

4. **(c) :** Given : least count = 0.01 and number of circular scale divisions = 50.

$\therefore$ Pitch = L.C × No. of circular scale division
= 0.01 × 50 = 0.5 mm.

5. **(c) :** $X = \frac{A^2 B^{1/2}}{C^{1/3} D^3}$

Maximum percentage error in X

$$\left(\frac{dX}{X}\right)\times 100 = \left(2\frac{dA}{A} + \frac{1}{2}\frac{dB}{B} + \frac{1}{3}\frac{dC}{C} + 3\frac{dD}{D}\right)\times 100$$

$$= 2\times 1 + \frac{1}{2}\times 2 + \frac{1}{3}\times 3 + 3\times 4 = 16\%$$

6. **(c) :** If n divisions of vernier scale coincides with $(n - 1)$ divisions of main scale.

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

$\Rightarrow$ 1 VSD = $\frac{(n-1)}{n}$ MSD

$\therefore$ Least count = 1 MSD − 1 VSD = 1 MSD − $\frac{(n-1)}{n}$ MSD

$= 1\text{ MSD} - 1\text{ MSD} + \frac{1}{n}\text{ MSD} = \frac{1}{n}\text{ MSD}$

$= \frac{1}{n}\times\frac{1}{n} = \frac{1}{n^2}$ cm $\quad \left[\because 1\text{ MSD} = \frac{1}{n}\text{ cm}\right]$

7. **(d) :** Diameter of the ball
= MSR + CSR × (Least count) – Zero error
= 5 mm + 25 × 0.001 cm – (–0.004) cm
= 0.5 cm + 25 × 0.001 cm – (–0.004) cm = 0.529 cm.

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

% 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 × 1% + 2 × 2% + 3% + 4%] = 14%

9. **(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,

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

According to problem

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

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

10. (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 × 2% = 6%

11. (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

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

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

12. (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

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

13. (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

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

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

14. (b) : 9.99 – 0.0099 = 9.9801 m

Least number of significant figure are 3. Hence, required answer will be 9.98 m.

15. (d) : We know, stress = $\frac{\text{Force}}{\text{Area}}$

Dimensions of force is $[M^1L^1T^{-2}]$ and that of area is $[L^2]$.

∴ Dimensions of stress = $\frac{[M^1L^1T^{-2}]}{[L^2]} = [M^1L^{-1}T^{-2}]$.

16. (c) : Impulse = Force × time
= $[MLT^{-2}][T] = [MLT^{-1}]$

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

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 $[ML^2T^{-2}]$.

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

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

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

18. (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 $ML^{-1}T^{-2}$

19. (d) : Pressure,

$$P = \frac{\text{force}}{\text{area}} = \frac{\text{mass } \times \text{ acceleration}}{\text{area}}$$

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

∴ $a = 1, b = -1, c = -2.$

20. (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.

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

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

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

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

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

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

23. (a) : Gravitational constant G

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

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

24. (c) : Dimensions of Planck's constant

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

Dimensions of angular momentum L
= Moment of inertia (I) × Angular velocity (ω)
= $[ML^2][T^{-1}] = [ML^2T^{-1}]$

25. (b) : Dimensions of force = $[MLT^{-2}]$
Dimensions of impulse = $[MLT^{-1}]$.

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

29. (b) : Pressure = $\dfrac{\text{Force}}{\text{Area}}$

Therefore dimensions of pressure = $\dfrac{\text{Force}}{\text{Area}} = ML^{-1}T^{-2}$.

30. (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 $\dfrac{E}{v} = \dfrac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

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

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

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

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

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

32. (a) : Permeability of free space

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

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

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

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

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

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

Dimensional formula for coefficient of viscocity

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

34. (c) : Induced emf $|\varepsilon| = L\dfrac{dI}{dt}$

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

$\therefore$ Dimensional formula of

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

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

36. (a) : Capacitance $C = \dfrac{\text{Charge}}{\text{Potential difference}}$

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

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

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

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.

37. (d) : Angular momentum L
= Moment of inertia I × Angular velocity ω.
$\therefore$ Dimensional formula $L = [ML^2][T^{-1}]$
$= [ML^2T^{-1}]$

38. (d) : Dimensions of $\dfrac{e^2}{4\pi\varepsilon_0} = [F \times d^2] = [ML^3T^{-2}]$

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

$l \propto \left(\dfrac{e^2}{4\pi\varepsilon_0}\right)^p G^q c^r$

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

On comparing both sides and solving, we get

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

$$\therefore\ l \propto \frac{1}{c^2}\left[\frac{Ge^2}{4\pi\varepsilon_0}\right]^{1/2}$$

39. (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), we get $l=K\dfrac{\sqrt{hG}}{c^{3/2}}$

40. (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 $x = 1$, $y = -1$, $z = -1$

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

or $\quad m = kF^aV^bT^c$ ...(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), $[m] = [FV^{-1}T]$

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

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

43. (b) : $v=at+\dfrac{b}{t+c}$

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

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

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

44. (c) : Equation $\left(P+\dfrac{a}{V^2}\right)=b\,\dfrac{\theta}{V}$. Since $\dfrac{a}{V^2}$ is added to the pressure, therefore dimensions of $\dfrac{a}{V^2}$ and pressure (P) will be the same.

And dimensions of $\dfrac{a}{V^2}=\dfrac{a}{[L^3]^2}=[ML^{-1}T^{-2}]$

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

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

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

Dimensions of $r = [L]$

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

Dimensions of $l = [L]$

$$\therefore\quad \text{Dimensions of } \eta = \frac{[P][r^2-x^2]}{[4vl]}$$

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

47. (b) : Given : $p=p_0e^{-\alpha t^2}$

αt^2 is a dimensionless $\quad\therefore\ \alpha=\dfrac{1}{t^2}=\dfrac{1}{[T^2]}=[T^{-2}]$

48. (c) : Let $k = P^xS^yc^z$ ...(i)

k is a dimensionless

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

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

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

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

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

49. (d) : $f = am^xk^y$ .....(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

$x + y = 0$

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

50. (c) : Units of $b=\dfrac{x}{t^2}=\dfrac{km}{s^2}$

❖❖❖