1 Physical World, Units and Measurements

Trend Analysis with Important Topics & Sub-Topics

		2020		2019		2018		2017		2016	
Topic	**Sub-Topic**	**Qns.**	**LOD**	**Qns.**	**LOD**	**Qns.**	**LOD**	**Qns.**	**LOD**	**Qns.**	**LOD**
Units of Physical Quantities	Units of Physical Quantities			1	E						
Dimensions of Physical Quantities	Dimensions of Physical Q.	1	E								
	Application of Dimensions							1	A	1	A
Errors in Measurements	Relative & % Error			1	E						
	Diameter = MSR + CSR (L.C.) – Zero error	1	A			1	A				
	Significant figures	1	E								

LOD - Level of Difficulty | **E - Easy** | **A - Average** | **D - Difficult** | **Qns - No. of Questions**

Topic 1: Units of Physical Quantities

1. The unit of thermal conductivity is : ***[2019]***
   (a) $J\,m\,K^{-1}$ (b) $J\,m^{-1}\,K^{-1}$
   (c) $W\,m\,K^{-1}$ (d) $W\,m^{-1}\,K^{-1}$
2. The density of 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 ***[2011M]***
   (a) 0.4 (b) 40
   (c) 400 (d) 0.04
3. The unit of permittivity of free space, ε_o is ***[2004]***
   (a) $\text{Coulomb}^2/(\text{Newton-metre})^2$
   (b) Coulomb/Newton-metre
   (c) $\text{Newton-meter}^2/\text{Coulomb}^2$
   (d) $\text{Coulomb}^2/\text{Newton-meter}^2$
4. The unit of the Stefan-Boltzmann's constant is ***[2002]***
   (a) W/m^2K^4 (b) W/m^2
   (c) W/m^2K (d) W/m^2K^2
5. 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 ***[1994]***
   (a) 0.1 N (b) 1 N
   (c) 10 N (d) 100 N
6. 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 unit of b is ***[1989]***
   (a) km/s (b) kms
   (c) km/s^2 (d) kms^2

Topic 2: Dimensions of Physical Quantities

7. Dimensions of stress are : ***[2020]***
   (a) $[ML^2T^{-2}]$ (b) $[ML^0T^{-2}]$
   (c) $[ML^{-1}T^{-2}]$ (d) $[MLT^{-2}]$
8. 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) $c^2\left[G\dfrac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$ (b) $\dfrac{1}{c^2}\left[\dfrac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$
   (c) $\dfrac{1}{c}G\dfrac{e^2}{4\pi\varepsilon_0}$ (d) $\dfrac{1}{c^2}\left[G\dfrac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

9. 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) $[EV^{-2}T^{-1}]$

10. If dimensions of critical velocity υ_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 : ***[2015 RS]***
(a) –1, –1, 1 (b) –1, –1, –1
(c) 1, 1, 1 (d) 1, –1, –1

11. 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) $[F\,V^{-1}\,T]$

12. The pair of quantities having same dimensions is ***[NEET Kar. 2013]***
(a) Young's modulus and energy
(b) impulse and surface tension
(c) angular momentum and work
(d) work and torque

13. The dimensions of $(\mu_0 \in_0)^{\frac{-1}{2}}$ are ***[2012M, 2011]***
(a) $[L^{1/2}T^{-1/2}]$ (b) $[L^{-1}T]$
(c) $[LT^{-1}]$ (d) $[L^{-1/2}T^{1/2}]$

14. The dimension of $\frac{1}{2}\varepsilon_0 E^2$, where ε_0 is permittivity of free space and E is electric field, is: ***[2010]***
(a) $[ML^2T^{-2}]$ (b) $[ML^{-1}T^{-2}]$
(c) $[ML^2T^{-1}]$ (d) $[MLT^{-1}]$

15. If the dimensions of a physical quantity are given by $M^aL^bT^c$, then the physical quantity will be: ***[2009]***
(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 $a = 1$, $b = -1$, $c = -2$

16. Which two of the following five physical parameters have the same dimensions? ***[2008]***
(A) Energy density
(B) Refractive index
(C) Dielectric constant
(D) Young's modulus
(E) Magnetic field
(a) (B) and (D) (b) (C) and (E)
(c) (A) and (D) (d) (A) and (E)

17. 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 ***[2007]***
(a) $[ML^2T^{-2}]$ (b) $[ML^2T^{-1}I^{-1}]$
(c) $[ML^2T^{-3}I^{-2}]$ (d) $[ML^2T^{-3}I{-}1]$

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

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

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

21. The dimensions of Planck's constant are same as ***[2001]***
(a) energy
(b) power
(c) momentum
(d) angular momentum

22. Which one of the following groups have quantities that do not have the same dimensions? ***[2000]***
(a) pressure, stress (b) velocity, speed
(c) force, impulse (d) work, energy

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

24. The force F on a sphere of radius 'a' is moving in a medium with velocity v is given by F = 6πηav. The dimensions of η are **[1997]**
(a) $[ML^{-3}]$ (b) $[ML^{-2}]$
(c) $[ML^{-1}]$ (d) $[ML^{-1}T^{-1}]$

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

26. Which of the following will have the dimensions of time **[1996]**
(a) LC (b) $\frac{R}{L}$
(c) $\frac{L}{R}$ (d) $\frac{C}{L}$

27. Which of the following is a dimensional constant? **[1995]**
(a) Refractive index
(b) Poissons ratio
(c) Relative density
(d) Gravitational constant

28. 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 the time. The constant α **[1993]**
(a) is dimensionless
(b) has dimensions T^{-2}
(c) has dimensions T^2
(d) has dimensions of p

29. 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
$$\eta=\frac{p\left(r^2-x^2\right)}{4vl}$$
where v is the velocity of oil at a distance x from the axis of the tube. The dimensions of η are **[1993]**
(a) $[M^0L^0T^0]$ (b) $[MLT^{-1}]$
(c) $[ML^2T^{-2}]$ (d) $[ML^{-1}T^{-1}]$

30. 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 **[1992]**
(a) $x=1, y=1, z=1$
(b) $x=-1, y=1, z=1$
(c) $x=1, y=-1, z=1$
(d) $x=1, y=1, z=-1$

31. The dimensional formula for permeability μ is given by **[1991]**
(a) $[MLT^{-2}A^{-2}]$
(b) $[M^0L^1T]$
(c) $[M^0L^2T^{-1}A^2]$
(d) None of the above

32. According to Newton, the viscous force acting between liquid layers of area A and velocity gradient ΔV/ΔZ 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 **[1990]**
(a) $ML^{-2}T^{-2}$ (b) $M^0L^0T^0$
(c) ML^2T^{-2} (d) $ML^{-1}T^{-1}$

33. 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 $f=c\,m^x k^y$, where c is a dimensionless constant. The values of x and y are **[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) $x=-\frac{1}{2}, y=\frac{1}{2}$

34. The dimensional formula of pressure is **[1990]**
(a) $[MLT^{-2}]$ (b) $[ML^{-1}T^2]$
(c) $[ML^{-1}T^{-2}]$ (d) $[MLT^2]$

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

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

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

38. The dimensional formula for angular momentum is **[1988]**
(a) $[M^0L^2T^{-2}]$ (b) $[ML^2T^{-1}]$
(c) $[MLT^{-1}]$ (d) $[ML^2T^{-2}]$

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

Topic 3: Errors in Measurements

40. 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

41. 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

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

43. 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, **[NEET Odisha, 2019]**
(a) $\frac{1}{n(n+1)}$ cm (b) $\frac{1}{(n+1)(n-1)}$ cm
(c) $\frac{1}{n}$ cm (d) $\frac{1}{n^2}$ cm

44. 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) 0.521 cm (b) 0.525 cm
(c) 0.529 cm (d) 0.053 cm

45. 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) 10% (b) 7%
(c) 4% (d) 14%

46. 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: **[2008]**
(a) 4% (b) 6%
(c) 8% (d) 2%

47. 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 **[1996]**
(a) 7% (b) 9%
(c) 12% (d) 13%

48. 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 **[1995]**
(a) 12% (b) 10%
(c) 8% (d) 2%

49. In a vernier calliper N divisions of vernier scale coincides with (N – 1) divisions of main scale (in which length of one division is 1 mm). The least count of the instrument should be **[1994]**
(a) N (b) N – 1
(c) 1/10N (d) 1/N – 1

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

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

Hints & Solutions

1. (d) In steady state, the amount of heat flowing from one face to the other face in time dt is given by

$$H = \frac{kA(T_1 - T_2)dt}{\ell}$$

$\Rightarrow \frac{dH}{dt} = \frac{kA}{\ell}\Delta T$ (k = coefficient of thermal conductivity)

$$\therefore\ k = \frac{\ell dH}{A\ dt\ \Delta T}$$

Unit of $k = Wm^{-1}\ K^{-1}$

2. (b) In CGS system, density $d = 4\frac{g}{cm^3}$

unit of length = 1 cm
unit of mass = 1 g
And in another system of units
The unit of mass is 100g and unit of length is 10 cm, so substitute these values

$$\text{Density} = \frac{4\left(\frac{100g}{100}\right)}{\left(\frac{10}{10}cm\right)^3} = \frac{\left(\frac{4}{100}\right)}{\left(\frac{1}{10}\right)^3}\frac{(100g)}{(10cm)^3}$$

$$= \frac{4}{100}\times(10)^3\cdot\frac{100g}{(10cm)^3} = 40 \text{ unit}$$

NOTES Apart from fundamental and derived units, we have also used practical units *e.g.*, horse power (h.p.) is a practical units of power. Practical units may or may not belong to a system but can be expressed in any system of units.

3. (d) $\varepsilon_o = \frac{q^2}{(r^2)4\pi F}$

$\Rightarrow$ unit of ε_o is $(\text{coulomb})^2$/ newton-metre^2

4. (a) According to Stefan's law, $E = \sigma AT^4$
where, E is energy dissipated per second,
A = surface area
T = absolute temperature

$$\sigma = \frac{E}{AT^4} = \frac{W}{m^2K^4}$$

5. (a) As we know force = Mass × Acceleration
= Mass × length × time^{-2} = $(10g)(10\ cm)(0.1s)^{-2}$
= $(10^{-2}\ kg)\ (10^{-1}m)\ (10^{-1}s)^{-2} = 10^{-1}N$.

6. (c) Given, $x = at + bt^2$
where, x = distance in km
t = time in sec
By the principle of homogencity, the dimensions of each terms of a dimensional equation on both sides are the same.
So, from equation, $x = at + bt^2$
dimension of left side = $[L]$
dimension of right side should be = [L]
According to homogeneity's law,

$$[L] = [b][T^2]$$

$$[b] = \frac{[L]}{[T^{+2}]} = \text{dimension of acceleration}$$

so unit of b should be km/sec^2.

7. (c) Stress $= \frac{\text{Force}}{\text{Area}}$

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

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

8. (d) Let dimensions of length is related as,

$$[L] = [c]^x[G]^y\left[\frac{e^2}{4\pi\varepsilon_0}\right]^z$$

$\Rightarrow \dfrac{e^2}{4\pi\varepsilon_0} = [ML^3T^{-2}]$

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

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

Comparing both sides

$-y + z = 0 \Rightarrow y = z$ ...(i)

$x + 3y + 3z = 1$ ...(ii)

$-x - 4z = 0$ $(\because y = z)$ ...(iii)

From (i), (ii) and (iii)

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

Hence, $[L] = c^{-2}\left[G \cdot \dfrac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

9. (b) As we know that, surface tension(s) = $\dfrac{\text{Force}[F]}{\text{Length}[L]}$

So, $[S] = \dfrac{[MLT^{-2}]}{[L]} = [MT^{-2}]$

Energy, (E) = Force × Displacement,

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

Velocity (V) = $\dfrac{\text{displacement}}{\text{time}}$

$[V] = [LT^{-1}]$

Let surface tension expressed as,

$s = E^a V^b T^c$ where a, b, c are constant.

Put the value

$$\frac{[MLT^{-2}]}{[L]} = [ML^2T^{-2}]^a \left[\frac{L}{T}\right]^b [T]^c$$

From the principle of homogeneity,

Equating the dimension of LHS and RHS

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

$\Rightarrow$ $a = 1,\ 2a + b = 0,\ -2a - b + c = -2$

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

Hence, the dimensions of surface tension are $[E\,V^{-2}\,T^{-2}]$

NOTES: Length, mass and time are arbitrarily chosen as fundamental quantities in mechanics. In fact any three quantities in mechanics can be termed as fundamental as all other quantities can be expressed in terms of these. If force (F) and acceleration (a) are taken as fundamental quantities, then mass will be defined as force (F) and acceleration (a) will be termed as derived quantity.

10. (d) Applying dimensional method :

$v_c = \eta^x \rho^y r^z$

here,

dimension of critical velocity, $V_0 = [LT^{-1}]$

co-efficient of viscosity, $\eta = \dfrac{F}{6\pi rv}$

so dimension of $\eta = \dfrac{[MLT^{-2}]}{[L][LT^{-1}]} = [ML^{-1}T^{-1}]$

dimension of density, $\rho = \dfrac{[M]}{[L^3]} = [ML^{-3}]$

dimension of radius, $r = [L]$

Put these values in equation (i),

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

Equating powers both sides

$x + y = 0;\ -x = -1\ \therefore\ x = 1$

$1 + y = 0\ \therefore\ y = -1$

$-x - 3y + z = 1$

$-1 - 3(-1) + z = 1$

$-1 + 3 + z = 1$

$\therefore\ z = -1$

11. (d) Force = mass × acceleration

$\Rightarrow$ Mass = $\dfrac{\text{force}}{\text{acceleration}}$

$= \dfrac{\text{force}}{\text{velocity / time}} = [F\,V^{-1}\,T]$

12. (d) Work = Force × displacement

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

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

Torque = Force × force arm

= mass × acceleration × length

$= [M] \times [LT^{-2}] \times [L] = [M\,L^2T^{-2}]$

NOTES: If dimensions are given, physical quantity may not be unique as many physical quantities have same dimensions. *e.g.*, If the dimensional formula of a physical quantity is $[ML^2T^{-2}]$ it may be work or energy or torque.

13. (c) $(\mu_0\varepsilon_0)^{-1/2} = \dfrac{1}{\sqrt{\mu_0\varepsilon_0}} \Rightarrow c$ = speed of light

where ε_0 = permittivity of free space

μ_0 = permeability of free space

So dimensions of $(\mu_0\varepsilon_0)^{-1/2}$ will be $[LT^{-1}]$

14. (b) $\dfrac{1}{2}\varepsilon_0 E^2$ represents energy density *i.e.*, energy per unit volume.

$$\Rightarrow \left[\frac{1}{2}\varepsilon_0 E^2\right] = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$$

15. (d) Pressure $= \frac{\text{Force}}{\text{Area}}$

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

$\Rightarrow a = 1, b = -1, c = -2.$

16. (c) Energy density $= \frac{\text{Energy}}{\text{Volume}}$

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

Refractive index and dielectric constant have no dimensions.

Young's Modulus $= \frac{F}{A} \times \frac{l}{\Delta l}$

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

Magnetic field, $B = \frac{F}{i\ell} = \frac{[MLT^{-2}]}{[A][L]}$

$= [MT^{-2}A^{-1}]$.

17. (c) As we know that

$$R = \frac{[V]}{[I]} = \frac{w}{q \cdot i} = \frac{w}{i \cdot t \cdot i}$$

Dimension of Resistance

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

18. (d) Dimension of $a.t$ = dimension of velocity

$a.t = [LT^{-1}] \quad \Rightarrow \quad [a = LT^{-2}]$

Dimension of c = dimension of t

(two physical quantity of same dimension can only be added)

So, dimension of $c = [T]$

Dimension of $\frac{b}{t+c}$ = Dimension of velocity

$$\frac{b}{T+T} = [LT^{-1}][LT^{-1}] \Rightarrow [b \cdot T^{-1}] = [LT^{-1}]$$

$\Rightarrow b = [L]$

So, answer is $[LT^{-2}]$, $[L]$ and $[T]$

NOTES: A dimensionally correct equation may or may not be physically correct. In a dimensionally correct equation, the dimensions of each term on both sides of an equation must be the same.

19. (b) Dimension formula for the planck's constant, $h = [ML^2T^1]$

Dimension formula for the moment of inertia, $I = [ML^2]$

So, the ratio between the plank's constant and moment of inertia is

$$\Rightarrow \frac{h}{I} = \frac{[ML^2T^{-1}]}{[ML^2]} \Rightarrow [T^{-1}]$$

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

20. (b) $F = \frac{G M_1 m_2}{r^2} \Rightarrow G = \frac{F r^2}{M_1 m_2}$

$\therefore$ dimension of G is $\frac{[MLT^{-2}][L^2]}{[M][M]}$

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

21. (d) We know that $E = h\nu$

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

Angular momentum $= I\omega$

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

22. (c) Force has dimension $[MLT^{-2}]$ while impulse has dimension $[MLT^{-1}]$, both have different dimensions.

23. (a) Dimension of magnetic flux

= Dimension of magnetic field × Dimension of area

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

24. (d) $F = 6\pi\eta\, av$

$$\eta = \frac{F}{6\pi\, av} = \frac{[MLT^{-2}]}{[L][LT^{-1}]} = [ML^{-1}T^{-1}]$$

25. (a) $\left(P + \frac{a}{V^2}\right) = b\frac{\theta}{V}$

According to the principle of homogeneity quantity with same dimension can be added or subtracted.

Hence, Dimension of P = Dimension of $\frac{a}{V^2}$

$$\Rightarrow \text{Dimension of } \frac{\text{Force}}{\text{Area}} = \text{Dimension of } \frac{a}{V^2}$$

$$\Rightarrow \left[\frac{MLT^{-2}}{L^2}\right] = \frac{a}{[L^3]^2} \Rightarrow a = [M\,L^5\,T^{-2}]$$

NOTES: To get the dimensions of physical constant, we write any formula or equation incorporating the given constant and then by substituting the dimensional formula of all other quantities, we can find the dimensions of the required constant or coefficients.

26. (c) $\varepsilon = -L\dfrac{di}{dt}$ ....(1)

$\varepsilon = iR$ ....(2)

From (1) & (2), $iR = -L\dfrac{di}{dt}$

$\therefore$ Dimension of L.H.S. = Dimension of R.H.S.

$[A]\,R = L\,[AT^{-1}] \Rightarrow \dfrac{L}{R} = [T]$

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

27. (d) A quantity which has dimensions and a constant value is called dimensional constant. Therefore, gravitational constant (G) is a dimensional constant. Value of G = 6.67×10^{-11} $m^2/kg/sec^2$

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

NOTES: Relative density, refractive index and poisson ratio all the three are ratios, therefore they are dimensionless constants.
Angle is an exceptional physical quantity, which though is a ratio of two similar physical quantities $\left(\text{angle} = \dfrac{\text{arc}}{\text{radius}}\right)$ but still requires a unit but no dimensions.

28. (b) In $p = p_0 \exp(-\alpha t^2)$, where αt^2 where is dimensionless

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

29. (d) $\eta = \dfrac{p(r^2 - x^2)}{4vl} = \dfrac{[ML^{-1}T^{-2}][L^2]}{[LT^{-1}][L]}$

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

NOTES: According to the principle of homogeneity, the dimensions of each term on the L.H.S. must be equal to the dimensions of the terms on the R.H.S. Only then dimensional equation or formula is dimensionally correct.

30. (c) Let the expression, $\alpha = P^x S^y c^z$ ...(i)

and given that dimension of $\alpha = [M^0L^0T^0]$ ...(ii)

= dimensionless

Dimension fo radiation pressure $P = \dfrac{\text{Force}}{\text{Area}}$

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

Dimension of radiation energy/unit area unit time

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

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

By equation (i) we get,

So, the dimension of $\alpha = [ML^{-1}T^{-2}]^x\,[MT^{-3}]^y\,[LT^{-1}]^z$

According to equation (ii),

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

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

Applying the principle of homegenity of dimension we get,

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

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

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

After solving above three equation we get,

$x = 1;\ y = -1;\ z = 1$

NOTES: Try out the given alternatives.
When $x = 1, y = -1, z = 1$

$$P^xS^yc^z = P^1S^{-1}c^1 = \frac{Pc}{S}$$

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

31. (a) Permeability of free space,

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

So, dimensional formula

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

NOTES: Also find the dimensional formula by using the relation,

Speed of light, $c = \dfrac{1}{\sqrt{\mu_0\varepsilon_0}}$

32. (d) $F = -\eta A\dfrac{\Delta V}{\Delta Z}$

$\Rightarrow \eta = (-1)\dfrac{F\Delta Z}{A\Delta V}$

So dimensional formula of η

$\Rightarrow \dfrac{[MLT^{-2}][L]}{[L^2][LT^{-1}]}$

$\Rightarrow [ML^{-1}T^{-1}]$

33. (d) $f = c\, m^x k^y$;

Spring constant k = force/length.

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

$\Rightarrow x + y = 0, -2y = -1$ or $y = \dfrac{1}{2}$

Therefore, $x = -\dfrac{1}{2}$

NOTES: The method of dimensions cannot be used to derive relations other than product of power functions.

34. (c) Pressure = Force / Area

So dimensional formula

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

35. (a) τ = Force × distance

So dimensional formula,

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

36. (c) $L = \varepsilon\left(\dfrac{dt}{dI}\right) = \dfrac{W}{q}\left[\dfrac{di}{dt}\right] = \dfrac{W}{i\cdot t}\left[\dfrac{di}{dt}\right]$

or, $[L] = \dfrac{[ML^2T^{-2}][T]}{[AT][A]} = [ML^2T^{-2}A^{-2}]$

37. (d) For angular momentum, the dimensional formula is $[ML^2T^{-1}]$. For other three, it is $[ML^{-1}T^{-2}]$.

38. (b) Angular momentum

= Momentum of inertia × Angular velocity

So dimensional formula,

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

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

39. (a) $CR = \left(\dfrac{q}{V}\right)\left(\dfrac{V}{i}\right) \Rightarrow \left(\dfrac{i\cdot t}{i}\right) \Rightarrow t = \text{time}$

$= [T] = [M^0L^0T^1]$

RC is the time constant of the circuit.

40. (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.

$$\begin{array}{r} 9.99 \\ -\,0.0099 \\ \hline 9.9801 \\ \hline \end{array}$$

As the least number of decimal places is 3. So, answer should be 9.98 m.

41. (b) Least count of screw gauge = 0.01 mm

Least count

$= \dfrac{\text{Pitch}}{\text{No. of divisions on circular scale}}$

$\Rightarrow 0.01 \text{ mm} = \dfrac{\text{Pitch}}{50}$

$\Rightarrow$ Pitch = 0.5 mm

42. (b) Given, $x = \dfrac{A^2B^{1/2}}{C^{1/3}D^3}$

% error, $\dfrac{\Delta x}{x}\times 100 = 2\dfrac{\Delta A}{A}\times 100 + \dfrac{1}{2}\dfrac{\Delta B}{B}\times 100 + \dfrac{1}{3}\dfrac{\Delta C}{C}\times 100 + 3\dfrac{\Delta D}{D}\times 100$

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

$= 2\% + 1\% + 1\% + 12\% = 16\%$

43. (d) n VSD = $(n-1)$ MSD

$1\text{ VSD} = \dfrac{(n-1)}{n}\text{MSD}$

$\text{L.C.} = 1\text{ MSD} - 1\text{ VSD} = 1\text{ MSD} - \dfrac{(n-1)}{n}\text{MSD}$

$= \dfrac{1}{n}\text{MSD} = \dfrac{1}{n}\times\dfrac{1}{n} = \dfrac{1}{n^2}$

44. (c) Diameter of the ball

= MSR + CSR × (ℓeast count) – zero error

= 0.5 cm + 25 × 0.001 – (–0.004)

= 0.5 + 0.025 + 0.004 = 0.529 cm

45. (d) Given, $P = \dfrac{a^3b^2}{cd}$

Therefore, $\dfrac{\Delta P}{P}\times 100\% = 3\dfrac{\Delta a}{a}\times 100\% + 2\dfrac{\Delta b}{b}\times 100\% + \dfrac{\Delta c}{c}\times 100\% + \dfrac{\Delta d}{d}\times 100\%$

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

NOTES: When we multiply or divide two measured quantities, the relative error in the final result is equal to the sum of the relative errors in the measured quantities. And when we add or subtract two measured quantities the absolute error in the final result is equal to the sum of the absolute error in the measured quantities.

46. (b) Given, error in the measurement of radius of a sphere $\frac{\Delta r}{r}\times 100 = 2\%$

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

$\therefore$ Error in the volume $\frac{\Delta V}{V}\times 100$

$= \pm 3\cdot\frac{\Delta r}{r}\times 100 = 3\times 2\% = \pm 16\%$

47. (d) As we know, density $= \frac{\text{mass}}{\text{volume}}$

Maximum error in the measurement of density

$\rho = \frac{M}{L^3}$

$\therefore \quad \frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 3\frac{\Delta L}{L}$

% error in density = % error in Mass
+3 (% error in length)
= 4 + 3(3) = 13%

48. (c) Percentage error in mass $\left(\frac{\Delta m}{m}\times 100\right) = 2$ and percentage error in speed $\left(\frac{\Delta v}{v}\times 100\right) = 3$.

Kinetic energy, $k = \frac{1}{2}mv^2$.

$\therefore$ Error in measurement of kinetic energy

$\frac{\Delta K}{K} = \frac{\Delta m}{m} + 2\left(\frac{\Delta v}{v}\right)$

$= \left(\frac{2}{100}\right) + \left(2\times\frac{3}{100}\right) = \frac{8}{100} = 8\%$

$\therefore$ %age error = 8%.

49. (c) Least count = 1MSD – 1 VSD

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

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

NOTES: Smaller value of the least count, higher is the accuracy of measurement. Accuracy of measurement is higher when number of significant figure after the decimal in measurement is larger.

50. (b) Density, $D = \frac{\text{Mass(M)}}{\text{Volume(V)}}$

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