SOLUTIONS TO CONCEPTS
CHAPTER – 1

1. a) Linear momentum : $mv = [MLT^{-1}]$

   b) Frequency : $\frac{1}{T} = [M^0L^0T^{-1}]$

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

2. a) Angular speed $\omega = \theta/t = [M^0L^0T^{-1}]$

   b) Angular acceleration $\alpha = \frac{\omega}{t} = \frac{M^0L^0T^{-2}}{T} = [M^0L^0T^{-2}]$

   c) Torque $\tau = F\,r = [MLT^{-2}]\,[L] = [ML^2T^{-2}]$

   d) Moment of inertia $= Mr^2 = [M]\,[L^2] = [ML^2T^0]$

3. a) Electric field $E = F/q = \frac{MLT^{-2}}{[IT]} = [MLT^{-3}I^{-1}]$

   b) Magnetic field $B = \frac{F}{qv} = \frac{MLT^{-2}}{[IT][LT^{-1}]} = [MT^{-2}I^{-1}]$

   c) Magnetic permeability $\mu_0 = \frac{B \times 2\pi a}{I} = \frac{MT^{-2}I^{-1}] \times [L]}{[I]} = [MLT^{-2}I^{-2}]$

4. a) Electric dipole moment $P = qI = [IT] \times [L] = [LTI]$

   b) Magnetic dipole moment $M = IA = [I]\,[L^2]\,[L^2I]$

5. $E = h\nu$ where E = energy and ν = frequency.

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

6. a) Specific heat capacity $= C = \frac{Q}{m\Delta T} = \frac{[ML^2T^{-2}]}{[M][K]} = [L^2T^{-2}K^{-1}]$

   b) Coefficient of linear expansion $= \alpha = \frac{L_1 - L_2}{L_0\Delta T} = \frac{[L]}{[L][R]} = [K^{-1}]$

   c) Gas constant $= R = \frac{PV}{nT} = \frac{[ML^{-1}T^{-2}][L^3]}{[(mol)][K]} = [ML^2T^{-2}K^{-1}(mol)^{-1}]$

7. Taking force, length and time as fundamental quantity

   a) Density $= \frac{m}{V} = \frac{(\text{force/acceleration})}{\text{Volume}} = \frac{[F/LT^{-2}]}{[L^2]} = \frac{F}{L^4T^{-2}} = [FL^{-4}T^2]$

   b) Pressure $= F/A = F/L^2 = [FL^{-2}]$

   c) Momentum = mv (Force / acceleration) × Velocity $= [F / LT^{-2}] \times [LT^{-1}] = [FT]$

   d) Energy $= \frac{1}{2}mv^2 = \frac{\text{Force}}{\text{acceleration}} \times (\text{velocity})^2$

   $= \left[\frac{F}{LT^{-2}}\right] \times [LT^{-1}]^2 = \left[\frac{F}{LT^{-2}}\right] \times [L^2T^{-2}] = [FL]$

8. $g = 10\frac{\text{metre}}{\text{sec}^2} = 36 \times 10^5\ \text{cm/min}^2$

9. The average speed of a snail is 0.02 mile/hr

   Converting to S.I. units, $\frac{0.02 \times 1.6 \times 1000}{3600}$ m/sec [1 mile = 1.6 km = 1600 m] $= 0.0089\ ms^{-1}$

   The average speed of leopard = 70 miles/hr

In SI units = 70 miles/hour = $\frac{70 \times 1.6 \times 1000}{3600}$ = 31 m/s

10. Height h = 75 cm, Density of mercury = 13600 kg/m^3, g = 9.8 ms^{-2} then
Pressure = hfg = 10 × 10^4 N/m^2 (approximately)
In C.G.S. Units, P = 10 × 10^5 dyne/cm^2

11. In S.I. unit 100 watt = 100 Joule/sec
In C.G.S. Unit = 10^9 erg/sec

12. 1 micro century = 10^4 × 100 years = 10^{-4} × 365 × 24 × 60 min
So, 100 min = 10^5 / 52560 = 1.9 microcentury

13. Surface tension of water = 72 dyne/cm
In S.I. Unit, 72 dyne/cm = 0.072 N/m

14. K = kI^a ω^b where k = Kinetic energy of rotating body and k = dimensionless constant
Dimensions of left side are,
K = [ML^{2}T^{-2}]
Dimensions of right side are,
I^a = [ML^2]^a, ω^b = [T^{-1}]^b
According to principle of homogeneity of dimension,
[ML^{2}T^{-2}] = [ML^{2}T^{-2}] [T^{-1}]^b
Equating the dimension of both sides,
2 = 2a and –2 = –b ⇒ a = 1 and b = 2

15. Let energy E ∝ M^{a}C^b where M = Mass, C = speed of light
⇒ E = KM^{a}C^b (K = proportionality constant)
Dimension of left side
E = [ML^{2}T^{-2}]
Dimension of right side
M^a = [M]^a, [C]^b = [LT^{-1}]^b
∴ [ML^{2}T^{-2}] = [M]^a[LT^{-1}]^b
⇒ a = 1; b = 2
So, the relation is E = KMC^2

16. Dimensional formulae of R = [ML^{2}T^{-3}I^{-2}]
Dimensional formulae of V = [ML^{2}T^{3}I^{-1}]
Dimensional formulae of I = [I]
∴ [ML^{2}T^{3}I^{-1}] = [ML^{2}T^{-3}I^{-2}] [I]
⇒ V = IR

17. Frequency f = KL^{a}F^{b}M^c M = Mass/unit length, L = length, F = tension (force)
Dimension of f = [T^{-1}]
Dimension of right side,
L^a = [L^a], F^b = [MLT^{-2}]^b, M^c = [ML^{-1}]^c
∴ [T^{-1}] = K[L]^a [MLT^{-2}]^b [ML^{-1}]^c
M^{0}L^{0}T^{-1} = KM^{b+c} L^{a+b-c} T^{-2b}
Equating the dimensions of both sides,
∴ b + c = 0 ...(1)
–c + a + b = 0 ...(2)
–2b = –1 ...(3)

Solving the equations we get,

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

$\therefore$ So, frequency $f = KL^{-1}F^{1/2}M^{-1/2} = \frac{K}{L}F^{1/2}M^{-1/2} = \frac{K}{L} = \sqrt{\frac{F}{M}}$

18. a) $h = \frac{2S\cos\theta}{\rho rg}$

LHS = [L]

Surface tension = $S = F/l = \frac{MLT^{-2}}{L} = [MT^{-2}]$

Density = $\rho = M/V = [ML^{-3}T^{0}]$

Radius = r = [L], g = $[LT^{-2}]$

$RHS = \frac{2S\cos\theta}{\rho rg} = \frac{[MT^{-2}]}{[ML^{-3}T^{0}][L][LT^{-2}]} = [M^{0}L^{1}T^{0}] = [L]$

LHS = RHS

So, the relation is correct

b) $v = \sqrt{\frac{p}{\rho}}$ where v = velocity

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

Dimension of p = F/A = $[ML^{-1}T^{-2}]$

Dimension of ρ = m/V = $[ML^{-3}]$

$RHS = \sqrt{\frac{p}{\rho}} = \sqrt{\frac{[ML^{-1}T^{-2}]}{[ML^{-3}]}} = [L^{2}T^{-2}]^{1/2} = [LT^{-1}]$

So, the relation is correct.

c) $V = (\pi pr^{4}t) / (8\eta l)$

LHS = Dimension of V = $[L^{3}]$

Dimension of p = $[ML^{-1}T^{-2}]$, $r^{4} = [L^{4}]$, t = [T]

Coefficient of viscosity = $[ML^{-1}T^{-1}]$

$RHS = \frac{\pi pr^{4}t}{8\eta l} = \frac{[ML^{-1}T^{-2}][L^{4}][T]}{[ML^{-1}T^{-1}][L]}$

So, the relation is correct.

d) $v = \frac{1}{2\pi}\sqrt{(mgl/l)}$

LHS = dimension of v = $[T^{-1}]$

$RHS = \sqrt{(mgl/l)} = \sqrt{\frac{[M][LT^{-2}][L]}{[ML^{2}]}} = [T^{-1}]$

LHS = RHS

So, the relation is correct.

19. Dimension of the left side = $\int \frac{dx}{\sqrt{(a^{2}-x^{2})}} = \int \frac{L}{\sqrt{(L^{2}-L^{2})}} = [L^{0}]$

Dimension of the right side = $\frac{1}{a}\sin^{-1}\left(\frac{a}{x}\right) = [L^{-1}]$

So, the dimension of $\int \frac{dx}{\sqrt{(a^2 - x^2)}} \neq \frac{1}{a}\sin^{-1}\left(\frac{a}{x}\right)$

So, the equation is dimensionally incorrect.

20. Important Dimensions and Units :

Physical quantity	Dimension	SI unit
Force (F)	$[M^1L^1T^{-2}]$	newton
Work (W)	$[M^1L^2T^{-2}]$	joule
Power (P)	$[M^1L^2T^{-3}]$	watt
Gravitational constant (G)	$[M^{-1}L^3T^{-2}]$	$N\text{-}m^2/kg^2$
Angular velocity (ω)	$[T^{-1}]$	radian/s
Angular momentum (L)	$[M^1L^2T^{-1}]$	$kg\text{-}m^2/s$
Moment of inertia (I)	$[M^1L^2]$	$kg\text{-}m^2$
Torque (τ)	$[M^1L^2T^{-2}]$	N-m
Young's modulus (Y)	$[M^1L^{-1}T^{-2}]$	N/m^2
Surface Tension (S)	$[M^1T^{-2}]$	N/m
Coefficient of viscosity (η)	$[M^1L^{-1}T^{-1}]$	$N\text{-}s/m^2$
Pressure (p)	$[M^1L^{-1}T^{-2}]$	N/m^2 (Pascal)
Intensity of wave (I)	$[M^1T^{-3}]$	$watt/m^2$
Specific heat capacity (c)	$[L^2T^{-2}K^{-1}]$	J/kg-K
Stefan's constant (σ)	$[M^1T^{-3}K^{-4}]$	$watt/m^2\text{-}k^4$
Thermal conductivity (k)	$[M^1L^1T^{-3}K^{-1}]$	watt/m-K
Current density (j)	$[I^1L^{-2}]$	$ampere/m^2$
Electrical conductivity (σ)	$[I^2T^3M^{-1}L^{-3}]$	$\Omega^{-1}\,m^{-1}$
Electric dipole moment (p)	$[L^1I^1T^1]$	C-m
Electric field (E)	$[M^1L^1I^{-1}T^{-3}]$	V/m
Electrical potential (V)	$[M^1L^2I^{-1}T^{-3}]$	volt
Electric flux (Ψ)	$[M^1T^3I^{-1}L^{-3}]$	volt/m
Capacitance (C)	$[I^2T^4M^{-1}L^{-2}]$	farad (F)
Permittivity (ε)	$[I^2T^4M^{-1}L^{-3}]$	$C^2/N\text{-}m^2$
Permeability (μ)	$[M^1L^1I^{-2}T^{-3}]$	$Newton/A^2$
Magnetic dipole moment (M)	$[I^1L^2]$	N-m/T

Magnetic flux (ϕ)	$[M^1L^2I^{-1}T^{-2}]$	Weber (Wb)
Magnetic field (B)	$[M^1I^{-1}T^{-2}]$	tesla
Inductance (L)	$[M^1L^2I^{-2}T^{-2}]$	henry
Resistance (R)	$[M^1L^2I^{-2}T^{-3}]$	ohm (Ω)