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 \(\omega = \frac{\theta}{t} = [M^0L^0T^{-1}]\)

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

c) Torque \(\tau = Fr = [MLT^{-2}]\ [L] = [ML^2T^{-2}]\)

d) Moment of inertia = \(Mr^2 = [M] [L^2] = [ML^2T^{-2}]\)

3. a) Electric field \(E = \frac{F}{q} = [MLT^{-2}]\)

b) Magnetic field \(B = \frac{F}{qv} = \frac{[MLT^{-2}]}{[L][T][L^{-1}]} = [MT^{-1}]\)

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

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

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

5. \(E = \hbar \nu\) where \(E = \text{energy and } \nu = \text{frequency.}\)

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

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

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

7. Taking force, length and time as fundamental quantity

a) Density \(= \frac{m}{V} = \frac{\text{mass}}{\text{volume}} = \frac{[F/LT^{-2}]}{[L^3]} = \frac{F}{L^4T^{-2}} = [FL^{-4}T^{-2}]\)

b) Pressure = \(\frac{F}{A} = \frac{F}{L^2} = [FL^{-2}]\)

c) Momentum = \(mv = \text{(force/acceleration)} \times \text{velocity} = \frac{[F/LT^{-2}]}{[LT^{-1}]} = [FT]\)

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. \(g = 10 \frac{\text{metres}}{\text{sec}^2} = 36 \times 10^5 \text{ cm/min}^2\)

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

Converting to S.I. units, \(\frac{0.02 \times 1.6 \times 1000}{3600} = 0.0089 \text{ m/s}^{-1}\)

The average speed of leopard = 70 miles/hr

In SI units = \(\frac{70 \times 1.6 \times 1000}{3600} = 31 \text{ m/s}\)
10. Height $h = 75$ cm, Density of mercury = $13600$ kg/m$^3$, $g = 9.8$ ms$^{-2}$ then

Pressure $= hf = 10 \times 10^4$ N/m$^2$ (approximately)

In C.G.S. Units, $P = 10 \times 10^6$ dyne/cm$^2$

11. In S.I. unit 100 watt = 100 Joule/sec

In C.G.S. Unit = $10 \times 10^5$ erg/sec

12. 1 micro century = $10^5 \times 100$ years = $10^{-4} \times 365 \times 24 \times 60$ 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. \[ K = kI^a \omega^b \] where $k = \text{Kinetic energy of rotating body and } k = \text{dimensionless constant}$

Dimensions of left side are,

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

Dimensions of right side are,

$I^a = [ML^2]^a, \omega^b = [T^{-1}]^b$

According to principle of homogeneity of dimension,

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

Equating the dimension of both sides,

$2 = 2a$ and $-2 = -b$ \(\Rightarrow a = 1\) and $b = 2$

15. Let energy $E \propto M^aC^b$ where $M = \text{Mass, } C = \text{speed of light}$

\(\Rightarrow E = KM^aC^b\) (K = proportionality constant)

Dimension of left side

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

Dimension of right side

$M^a = [M]^a, [C]^b = [LT^{-1}]^b$

\(\therefore [ML^2T^{-2}] = [ML]^a[L^{-1}]^b\)

\(\Rightarrow a = 1; b = 2\)

So, the relation is $E = KM^aC^b$

16. Dimensional formulae of $R = [ML^2T^{-3}I^{-1}]$

Dimensional formulae of $V = [ML^2T^3I^1]$

Dimensional formulae of $I = [I]$

\(\therefore [ML^2T^{-3}I^{-1}] = [ML^2T^3I^1] [I]\)

\(\Rightarrow V = IR\)

17. Frequency $f = KL^aF^bM^c$ $M = \text{Mass/unit length, } L = \text{length, } F = \text{tension (force)}$

Dimension of $f = [T^{-1}]$

Dimension of right side,

$L^a = [L^a], F^b = [MLT^{-2}]^b, M^c = [ML^{-1}]^c$

\(\therefore [T^{-1}] = K[L]^a[MLT^{-2}]^b[ML^{-1}]^c\)

$M^0L^0T^{-1} = KM^{b+c}L^{a+b-c}T^{-2b}$

Equating the dimensions of both sides,

\(\therefore b + c = 0 \quad \ldots(1)\)

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

$-2b = -1 \quad \ldots(3)$

Solving the equations we get,

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

\(\therefore \text{So, frequency } f = KL^{-1}F^{1/2}M^{-1/2} = \frac{K}{L}F^{1/2}M^{-1/2} = \frac{K}{L} = \sqrt{\frac{F}{M}}\)
18. a) \( h = \frac{2SC\cos\theta}{\rho g} \)

LHS = [L]

Surface tension = \( S = \frac{F}{L} = \frac{MLT^{-2}}{L} = [MT^{-2}] \)

Density = \( \rho = \frac{M}{V} = [ML^{-3}T^0] \)

Radius = \( r = [L] \), \( g = [LT^{-2}] \)

RHS = \( \frac{2SC\cos\theta}{\rho g} = \frac{[MT^{-2}]}{[ML^{-3}T^0][L][LT^{-2}]} = [M^0L^0T^0] = [L] \)

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 \( \rho = m/V = [ML^{-3}] \)

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

So, the relation is correct.

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

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

So, the relation is correct.

d) \( v = \frac{1}{2\pi} \sqrt{\frac{mg}{l}} \)

LHS = Dimension of \( v = [T^{-1}] \)

RHS = \( \sqrt{\frac{mg}{l}} = \sqrt{\frac{[ML][L^2]}{[ML^2]}} = [T^{-1}] \)

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.
### Important Dimensions and Units:

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