Introduction to Physics

Exercise Solutions

Solution 1:

(i)

Linear momentum can be written as "mv"

Dimensions of Linear momentum: mv = $[MLT^{-1}]$

(ii) Frequency can be written as "1/T", where T is time.

Dimensions of Frequency: 1/T = $[M^0L^0T^{-1}]$

(iii) All units of pressure represent some ratio of force to area

So, dimensions of pressure: Force/Area = $\frac{[MLT^{-2}]}{[L^2]}$ = $[ML^{-1}T^{-2}]$

Solution 2:

(a) Dimensions of Angular speed, ω

We know, $\omega = \theta/t$

Dimensions are $[M^0L^0T^{-1}]$

(b) Dimensions of Angular acceleration, α

We know, $\alpha = \omega/t$

So required dimensions are = $\frac{[M^0L^0T^{-1}]}{[T]}$ = $[M^0L^0T^{-2}]$

[using (a) result)]

(c) Dimensions of Torque, τ and

We know, $\tau = Fr$

So, $\tau = [MLT^{-2}][L] = [ML^2T^{-2}]$

(d) Dimensions of Moment of Inertia, I

Here $I = Mr^2 = [M][L^2] = [ML^2T^0]$

Solution 3:

(a) Dimensions of Electric Field E = F/q = $\frac{[MLT^{-2}]}{[TI]}$ = $[MLT^{-3}I^{-1}]$

(b) Dimensions of Magnetic field B = F/qv = $\frac{[MLT^{-2}]}{[TI][LT^{-1}]}$ = $[MT^{-2}I^{-1}]$

(c) Dimensions of Magnetic permeability μ_0 = (Bx2 πa)/I = $\frac{[MT^{-2}I^{-1}][L]}{[I]}$ = $[MLT^{-2}I^{-2}]$

Solution 4:

a) Dimensions of Electric dipole moment p = ql = [IT] [L] = [LTI]
(b) Dimensions of Magnetic dipole moment M = IA = $[I][L^2]$ $[L^2I]$

Solution 5:
Planck's constant can be written as, h = E/v
Where E = energy and v = frequency

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

Solution 6:
(a) Dimensions of specific heat capacity,

c = Q/mΔT = $\frac{[ML^2T^{-2}]}{[M][K]}$ = $[L^2T^{-2}K^{-1}]$

(b) Dimensions of coefficient of linear expansion,

$\alpha = \frac{L_1-L_2}{L_0\,\Delta T} = \frac{[L]}{[L][R]} = K^{-1}$

(c) Dimensions of gas constant,

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

Solution 7:

As per given instruction, considering force, length and time to be the fundamental quantities

(a) Density = mass/volume ...(1)

and, mass = Force/acceleration = (Force × time^2)/displacement.

(1)=> Density = {(Force × time^2)/displacement}/Volume

Dimensions of Density = $[FL^{-4}T^{2}]$

(b)

Pressure = F/A

Dimensions of A = $[L^{2}]$

Dimensions of Pressure = $[FL^{-2}]$

(c)

Momentum = mv = (force/acceleration) x velocity

= $[F/LT^{-2}] \times [LT^{-1}] = [FT]$

Dimensions of Momentum [FT]

(d)

Energy = ½ mv^2 = Force/acceleration x $(\text{velocity})^2$

$$= \frac{[F]}{[LT^{-2}]} [LT^{-1}]^2 = [FL]$$

Dimensions of Energy = [FL]

Solution 8:

Given: acceleration due to gravity at a place is 10 m/s^2

Convert units into cm/min^2

Here, g = 10 m/sec^2 = 36×10^5 cm/min^2

Solution 9:
Average speed of a snail = 0.020 miles/hour (Given)
Average speed of a leopard = 70 miles/hour (Given)

In SI Units:
0.020 miles/hour = (0.02x1.6x1000)/3600 = 0.0089 m/s
[Using 1 mile = 1.6 km = 1600m]
And,
70 miles/hr = (70x1.6x1000)/3600 = 31 m/s

Solution 10:
The height of mercury column in a barometer in a Calcutta laboratory was recorded to be 75 cm. (Given)
Say, h = 75 cm
Calculate pressure in SI and CGS units.
Pressure = hρg = 10×10^4 N/m^2 approx

In C.G.S. units, Pressure = 10×10^5 $dyne/cm^2$

Solution 11:
Write power 100 watt in CGS units.

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

Solution 12:
Given: 1 microcentury = $10^{-6} \times 100$ years.
1 year = 365 x 24 x 60 min
Or 1 microcentury = $10^{-4} \times 365 \times 24 \times 60$ min
So, 100 min = $10^5/52560$ = 1.9 microcentury

Solution 13:
Given: surface tension of water is 72 dyne/cm

In S.I units: 72 dyne/cm = 0.072 N/m

Solution 14:
$K = kI^a \omega^b$; where k is a dimensionless constant, K = kinetic energy and ω = angular speed
To find: a and b
Now, $K = [ML^2T^{-2}]$

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

=> $[ML^2T^{-2}] = [ML^2]^a [T^{-1}]^b$
[using principle of homogeneity of dimension]

Equating the dimensions, we get
2a = 2 => a = 1
-b = -2 => b = 2

Solution 15:
The relationship between energy, mass and speed of light is,
$E \propto M^aC^b$
Where M = mass and C = speed of light
or $E = K M^aC^b$ ......(1)
where K = constant of proportionality

Find the dimensions of (1)

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

By comparing values, we have
a = 1 and b = 2
So, we have required relation is $E = KMC^2$

Solution 16:
Given:
Dimensional formulae for R = $[ML^2I^{-2}T^{-3}]$ and
Dimensional formulae for V = $[ML^2T^{-3}I^{-1}]$
Therefore,

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

=> V = IR

Solution 17:

L = length, M = mass and F = Force

Here, $f = KL^aF^bM^c$ ...(1)

Dimension of frequency, $f = [T^{-1}]$ or $[M^0L^0T^{-1}]$

Dimension of length, $L = [L]$

Dimension of mass, $M = [ML^{-1}]$

Dimension of force, $F = [MLT^{-2}]$

(1)=> $[M^0L^0T^{-1}] = K\,[L]^a\,[MLT^{-2}]^b\,[ML^{-1}]^c$

Equating both sides, we get

$b + c = 0$

$-c + a + b = 0$

$-2b = -1$

Solving above three equations , we have

$a = -1$, $b = ½$ and $c = -1/2$

Therefore, frequency is

$f = KL^{-1}F^{1/2}M^{-1/2}$

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

Solution 18:

(a) Dimension of h = [L]

Dimension of $S = F/l = MLT^{-2}/L = [MT^{-2}]$

Dimension of density = $M/V = [ML^{-3}T^0]$

Dimension of radius = [L]

Dimension of gravity = $[LT^{-2}]$

Now,

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

Relation is correct.

(b) Let velocity = $v = \sqrt{(p/\rho)}$ ....(1)

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

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

Dimension of ρ = m/v = $[ML^{-3}]$

Substituting dimensions in (1), we have

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

Therefore, relation is correct.

(c)
Dimension of V = $[L^3]$
Dimension of p = $[ML^{-1}T^{-2}]$
Dimension of r^4 = $[L^4]$
Dimension of t = [T]
Dimension of η = $[ML^{-1}T^{-1}]$

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

Therefore, relation is correct.

(d)
Dimension of v = $[T^{-1}]$
Dimension of m = [M]
Dimension of g = $[LT^{-2}]$
Dimension of l = [L]
Dimension of inertia = $[ML^2]$

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

Therefore, relation is correct.

Solution 19:

Dimensions of a = [L]
Dimensions of x = [L]

LHS

$$\int \frac{dx}{\sqrt{(a^2 - x^2)}} = \int \frac{L}{\sqrt{(L^2 - L^2)}} = [L^0]$$

RHS

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

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