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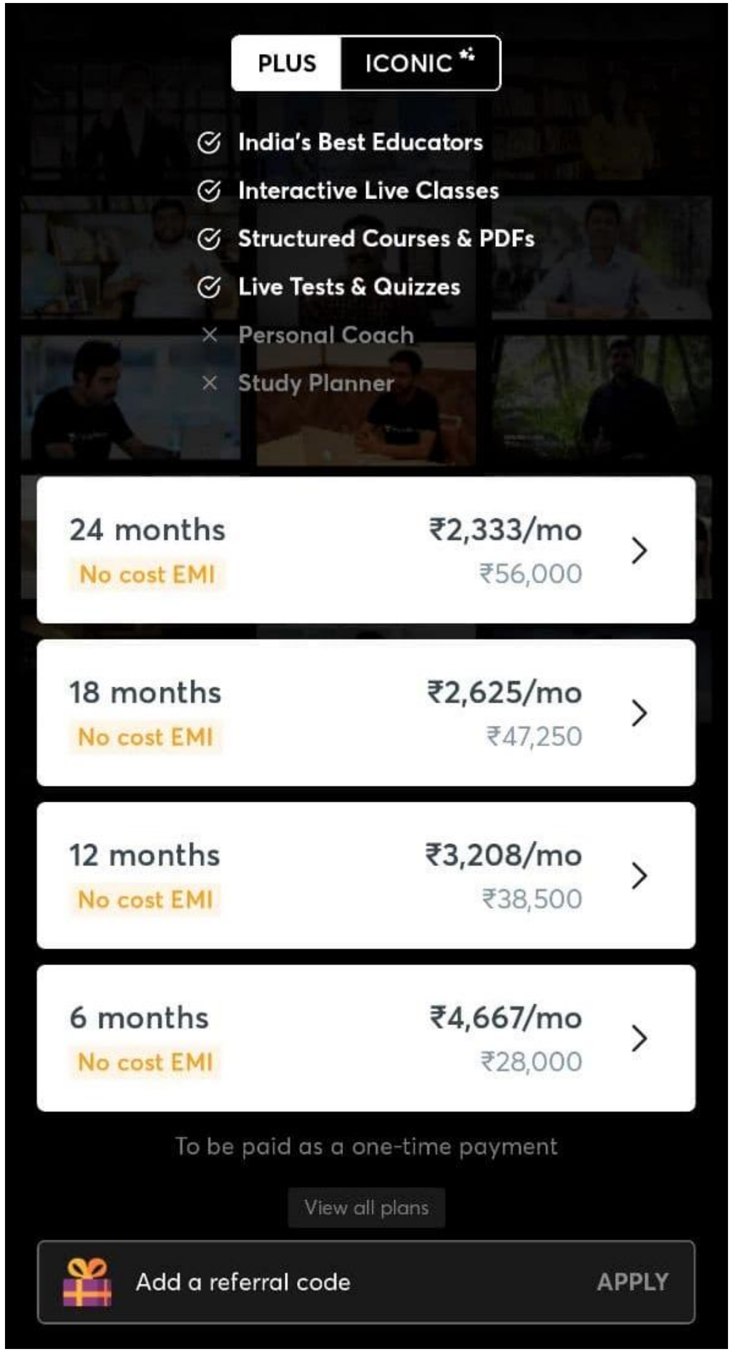

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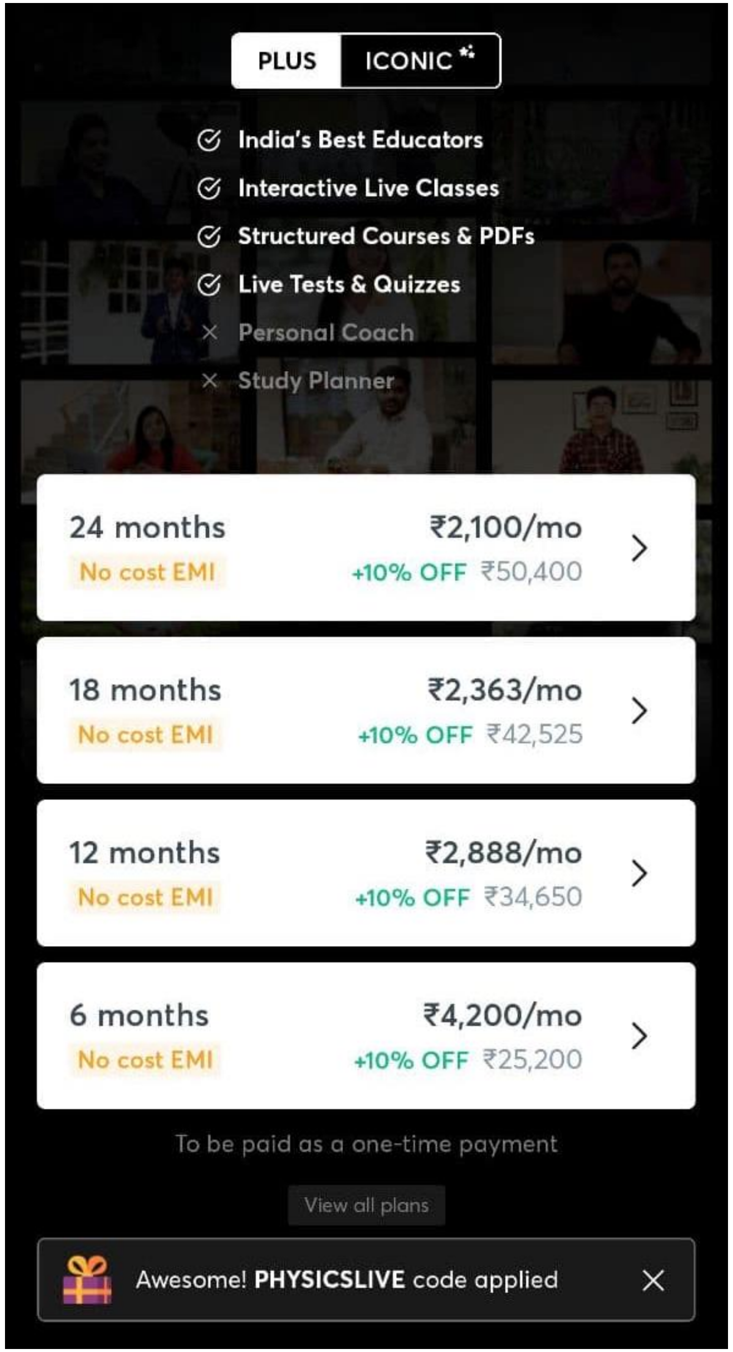

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JEE Advanced, NSEP, INPhO, IPhO
Physics DPP

DPP-1 Units & Measurements: Units & Dimensional Formula

By Physicsaholics Team

Q) The dimensions of shear modulus of rigidity are

[Hint: Shear modulus of rigidity = $\frac{\text{Shear Stress}}{\text{Shear Strain}}$, Shear Stress = $\frac{Tangential \text{ Force}}{Area}$,

Shear Strain = $\frac{\text{Relative displacement of any layer}}{\text{its distance from a fixed layer}}$]

(A) $M^1 L^1 T^{-2}$

(B) $M^1 L^1 T^{-1}$

(C) $M L^2 T^2$

(D) $M L^{-1} T^{-2}$

Ans. d

Solution:

Shear modulus of rigidity (η) = $\dfrac{\text{Shear stress}}{\text{Shear strain}}$

Shear strain (ϵ) = $\dfrac{\text{Relative displacement of any layer}}{\text{its distance from a fixed layer}} = \dfrac{m}{m}$

$[\epsilon] = M^0L^0T^0$

$[\epsilon]$ = Shear strain = dimensionless

so; $[\eta] = [\text{Shear stress}] = \left[\dfrac{\text{Tangential Force}}{\text{Area}}\right]$

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

$$\boxed{[\eta] = ML^{-1}T^{-2}}$$ Ans

Q) Using mass (M), length (L), time (T), and electric current (A) as fundamental quantities, the dimensions of permittivity will be

[Hint: $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$, ε_0 = permittivity; current (I) = $\frac{q}{t}$]

(A) [M LT^{-1} A^{-1}]

(B) [M LT^{-2} A^{-2}]

(C) [M^{-1} L^{-3} T^{4} A^{2}]

(D) [M2 L^{-2} T^{-2} A]

Ans. c

Solution:

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$$

$$\epsilon_0 = \frac{q_1 q_2}{4\pi F r^2}$$

$$[\epsilon_0] = \frac{[q]^2}{[F][r]^2}$$

$$I = \frac{q}{t}$$

$$[q] = [I][t]$$

$$[q] = AT$$

$$[\epsilon_0] = \frac{[AT]^2}{[MLT^{-2}][L]^2} = \frac{A^2T^2}{ML^3T^{-2}}$$

$$[\epsilon_0] = M^{-1}L^{-3}A^2T^4$$

Ans

Q) Which of the following does not have the same dimension?

(a) Electric flux, electric field, electric dipole moment

(b) pressure, stress, Young's modulus

(c) Electromotive force, potential difference, electric voltage

(d) Heat, potential energy, work done

Ans. a

(a) Solution:

Electric flux $= \phi$, Electric field $= E$, Electric dipole moment $(P = qd)$

Eletric field $(E) = \dfrac{\text{Force}}{\text{charge}}$; $q = It$; $[q] = AT$

$$[E] = \frac{[F]}{[q]} = \frac{MLT^{-2}}{AT} = MLA^{-1}T^{-3}$$

Electric flux $= \phi = EA \Rightarrow [\phi] = [E][A] = [MLA^{-1}T^{-3}][L^2]$

$A = $ Area

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

Electric dipole $(P) = qd \Rightarrow [P] = [q][d] = [AT][L]$

$$[P] = LAT$$

so; $[\phi] \neq [E] \neq [T]$

Solution:

(b)

Pressure (P) = $\frac{\text{Force}}{\text{Area}} = \frac{F}{A}$

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

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

Stress (σ) = $\frac{\text{Force}}{\text{Area}} = \frac{F}{A}$

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

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

so; $[P] = [\sigma] = [Y]$

Young's Modulus (Y) = $\frac{\text{Stress}}{\text{Strain}}$

$Y = \frac{(\text{Force}/\text{Area})}{\left(\frac{\text{Change in length}}{\text{original length}}\right)}$

$[Y] = \frac{[F/A]}{[\Delta l/l]} = \left[\frac{F}{A}\right]\left[\frac{l}{\Delta l}\right]$

$[Y] = \left[\frac{MLT^{-2}}{L^2}\right]\left[\frac{L}{L}\right]$

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

Solution:

(c) You will study about Electromotive force (EMF); Potential difference (V) and Electronic Voltage (Ve) and these quantities have same dimension.

(d) Unit of Heat (H) = Joule

Unit of Potential Energy (PE) = Joule

Unit of work done (W) = Joule

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

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

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

$[H] = [PE] = [W]$

Q) The dimensions $ML^{-1}T^{-2}$ may correspond to

[Hint: Linear momentum = mass × velocity, Energy density = $\frac{\text{Energy}}{\text{Volume}}$

(a) work

(b) linear momentum

(c) energy density

(d) All of these

Ans. c

Solution:

work (W) = Force × distance = F . d

$[W] = [F][d] = MLT^{-2} . L = ML^2T^{-2}$

Linear Momentum (P) = m . v

$[P] = [m][V] = M . LT^{-1} = MLT^{-1}$

Energy density (u) = $\frac{\text{Energy}}{\text{Volume}} = \frac{E}{Vol}$

$[u] = \frac{[E]}{[Vol.]} = \frac{ML^2T^{-2}}{L^3} = ML^{-1}T^{-2}$

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

So, $ML^{-1}T^{-2}$ = dimension of Energy density.

Q) A unitless quantity

(a) never has nonzero dimensions

(b) always has nonzero dimensions

(c) may have a nonzero dimension

(d) does not exist

Ans. a

Solution:

Unitless quantity can never has dimension.

So; Unitess quantity has Zero dimension

or, we can say that can not hav nonzero dimension.

Q) Which of the following quantities has a unit but no dimensions?

[Hint: $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$, ε_0 = Absolute permittivity, $F = \frac{Gm_1 m_2}{r^2}$, G = Gravitational Constant, Refractive index = $\frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}}$]

(a) Refractive index

(b) Absolute permittivity

(c) Gravitational Constant

(d) Solid angle

Ans. d

Solution:

(a) Refractive Index $(\mu) = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in medium}} = \frac{c}{v}$

$$[\mu] = \frac{[c]}{[v]} = \frac{LT^{-1}}{LT^{-1}} = L^0T^0$$

$[\mu]$ = Dimensionless & unitless

(b) Absolute permittivity $(\epsilon_0) = \frac{q_1 q_2}{4\pi F r^2}$; $[\epsilon_0] = \frac{[q]^2}{[F][r]^2}$

$[\epsilon_0] = M^{-1}L^{-3}A^2T^4$ [has dimensions & unit both]

(c) Gravitational Constant $(G) = \frac{Fr^2}{m_1 m_2}$ $[G] = \frac{MLT^{-2}L^2}{M \cdot M} = M^{-1}L^3T^{-2}$

[has dimensions & unit both]

(d) Solid Angle $(\Omega) \Rightarrow$ unit = steradian

Dimension = Dimensionless] Ans

Q) The dimensions of $\frac{\text{angular momentum}}{\text{magnetic moment}}$ are :

[Hint: angular momentum = mass × velocity × perpendicular distance, Magnetic moment = Current flowing in loop × Area of loop]

(a) $[M^3LT^{-2}A^2]$

(b) $[MA^{-1}T^{-1}]$

(c) $[ML^2A^{-2}T]$

(d) $[M^2 L^{-3}AT^2]$

Ans. b

Solution:

$$\frac{\text{Angular momentum } (L)}{\text{magnetic moment } (M_0)} = x$$

then $x = \frac{L}{M}$

$$[x] = \frac{[L]}{[M_0]} = \frac{[mvr]}{[IA]} = \frac{M \cdot L T^{-1} \cdot L}{A \cdot L^2}$$

$$\boxed{[x] = M A^{-1} T^{-1}} \text{ Ans}$$

Q) Which of the following is not a units of CR^2

[Hint: C = capacitance = $\frac{\text{Charge}}{\text{Voltage}}$ and R = resistance = $\frac{\text{Voltage}}{\text{Current}}$; Energy (E) of a charge (q) accelerated by voltage (V) = qV)

(a) Joule/ampere^2 (b) Volt - second /ampere

(c) Volt /ampere (d) None of these

Ans. c

Solution: $C = \frac{\text{charge}}{\text{Votage}} = \frac{q}{V}$; Resistance (R) = $\frac{\text{Voltage}}{\text{current}} = \frac{V}{I}$

Let; $CR^2 = x$

then; $x = CR^2 = \left(\frac{q}{V}\right) \times \left(\frac{V}{I}\right)^2 = \frac{qV}{I^2}$

And; $qV = E$ (Energy)

$x = \frac{E}{I^2}$; unit = Joule/Ampere² ✓

$\therefore I = \frac{q}{t} \Rightarrow q = It$

$x = \frac{qV}{I^2} = \frac{(It)V}{I^2} = \frac{tV}{I}$

$x = \frac{Vt}{I}$; unit = Volt-sec/Ampere ✓

So; Volt/Ampere is not a unit of "CR^2". Ans

Q) Units of $\frac{CV}{\rho\varepsilon_0}$ are of

(C = capacitance = $\frac{\varepsilon_0 A}{d}$, V = potential or voltage, ρ = specific resistance = $\frac{RA}{l}$; R = electric resistance and ε_0 = permittivity; current (I) = $\frac{q}{t} = \frac{V}{R}$

l and d are length and distance)

(a) charge (b) current (c) time (d) frequency

Ans. b

Solution:

let; $\frac{CV}{\rho\epsilon_0} = x$

then; $x = \frac{CV}{\rho\epsilon_0} = \frac{\frac{\epsilon_0 A}{d}\cdot V}{\left(\frac{VA}{lI}\right)\epsilon_0}$

$\rho = \frac{RA}{l}$; $R = \frac{V}{I}$

$\rho = \frac{VA}{lI}$

$x = \frac{Il}{d}$

Unit of x = Ampere × $\frac{\text{meter}}{\text{meter}}$

Unit of x = Ampere

Ans.

Q) Which of the following is not the unit of time ?

(a) leap year
(b) lunar month
(c) solar day
(d) parallactic second

Ans. d

Solution:

Leap Year: A leap year has 366 days instead of 365. (unit of time)

Lunar Month: A lunar month is the amount of time it takes for the Moon to pass through each of its phases and then return back to its original position. It takes 29 days, 12 hours, 44 minutes and 3 seconds for the Moon to complete one lunar month. (unit of time)

Solar Day: A solar day is the time it takes for the Earth to rotate about its axis so that the Sun appears in the same position in the sky. (unit of time)

Parallactic Second: Parallactic second or parsec is a unit of large distances used by the astronomers to measure large distances outside our solar system. (unit of distance)

[1 parallactic second $\approx 3.085 \times 10^{13}$ km

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Chalo Niklo