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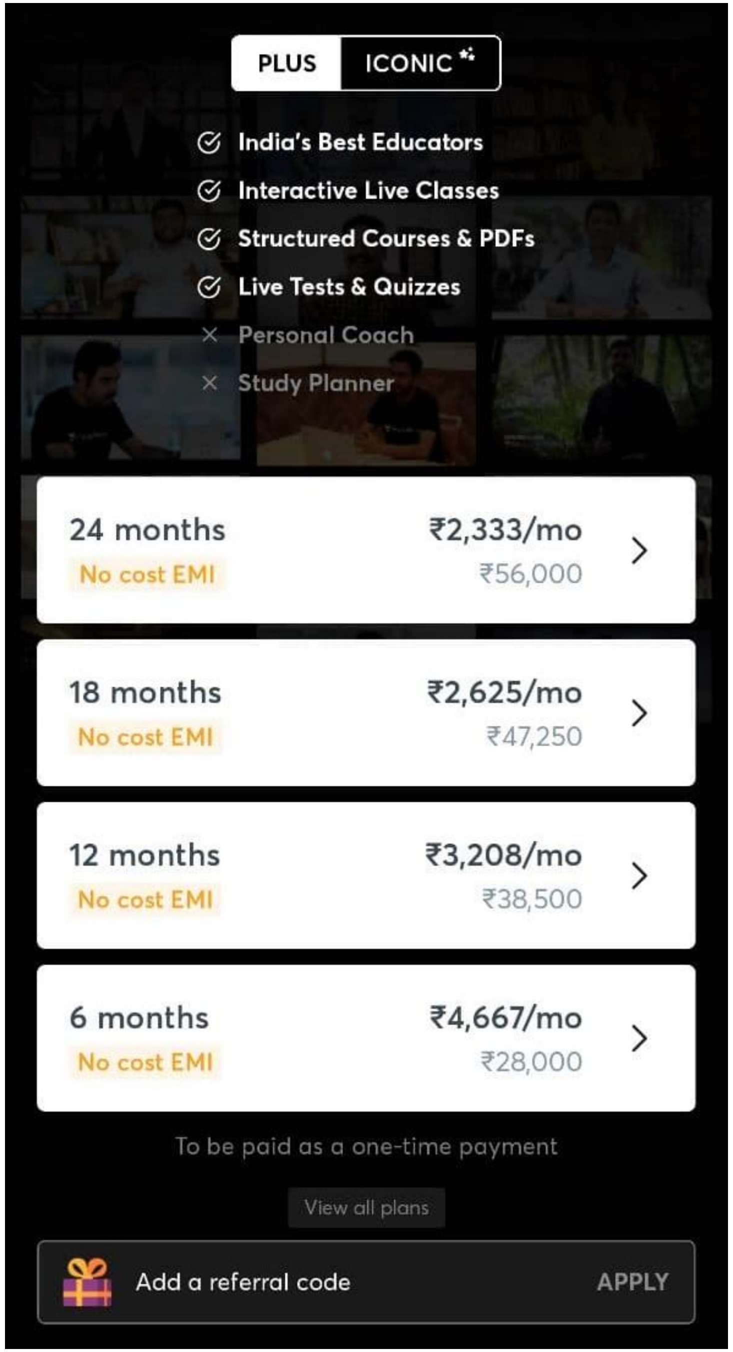

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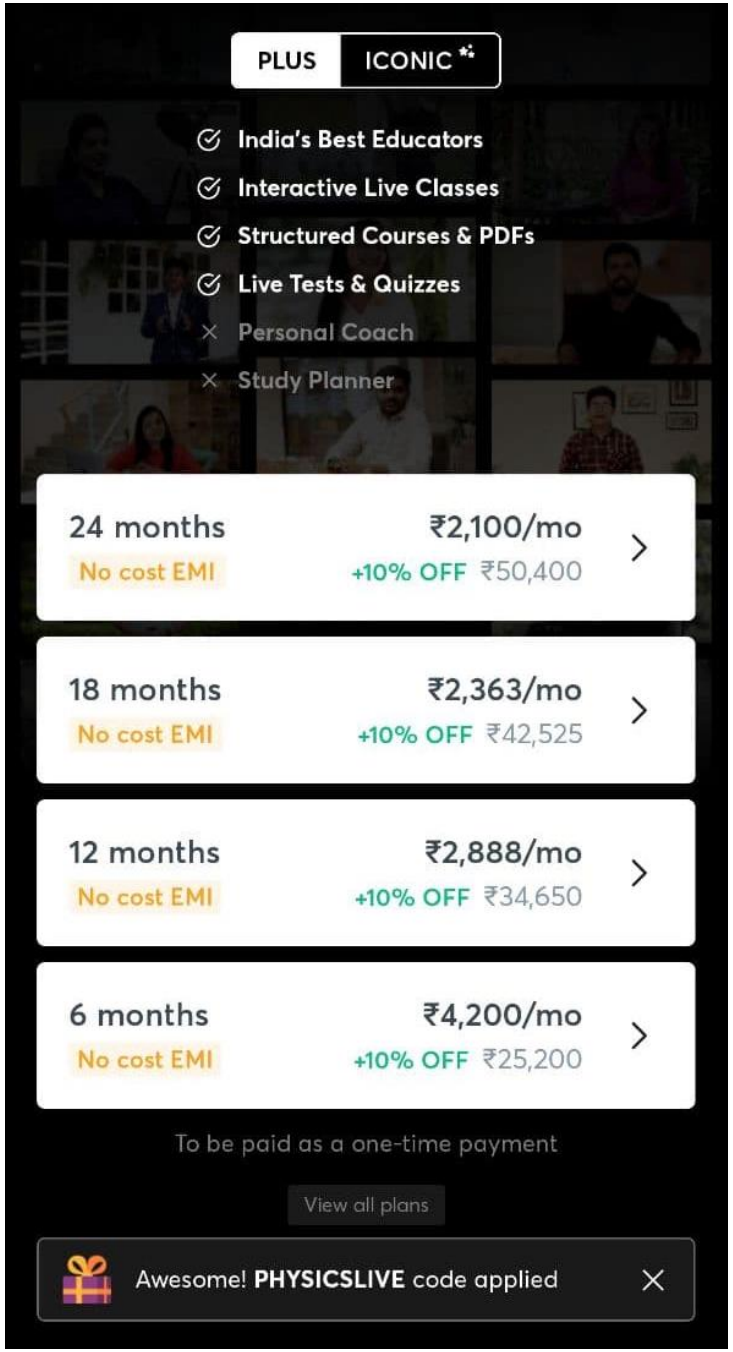

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JEE Advanced, NSEP, INPhO, IPhO
Physics DPP

DPP-2 Units & Measurements: Principle of Homogeneity

By Physicsaholics Team

Q) In the formula $P = P_0 e^{-\frac{hc}{x}}$, h is Planck's constant (Unit = J-s) and c is speed of light. The dimensional formula for x is

(a) $M^1L^2T^{-2}$
(b) $M^0L^1T^0$
(c) $M^1L^3T^{-2}$
(d) $M^0L^0T^0$

Ans. c

Solution:

$$P = P_0 e^{-\frac{hc}{x}}$$

$\because \frac{hc}{x}$ is in power of 'e', so it will be dimensionless.

$$\left[\frac{hc}{x}\right] = M^0 L^0 T^0$$

so, $[x] = [hc] = [h][c]$

$[x] = ML^2T^{-1} \cdot LT^{-1}$

$$\boxed{[x] = ML^3T^{-2}}$$ Ans

unit of h = J-S

$[h] = [J][S]$

$= ML^2T^{-2} \cdot T$

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

$$\boxed{[c] = LT^{-1}}$$

Q) In a book, the answer for a particular question is expressed as $b = \frac{ma}{k}\left[\sqrt{1 + \frac{2k\ell}{ma}}\right]$ here m represents mass, a represents acceleration, ℓ represents length. The unit of b should be

(a) m/s

(b) m/s^2

(c) meter

(d) sec^{-1}

Ans. c

Solution:

$$b = \frac{ma}{k}\left[\sqrt{1+\frac{2kl}{ma}}\right]$$

as; 1 is dimensionless

so; from; $\sqrt{1+\frac{2kl}{ma}}$ $\frac{2kl}{ma}$ is also dimensionless

as it is adding in '1' (dimensionless)

so; $\left[\frac{2kl}{ma}\right] = M^0L^0T^0$

$$[k] = \left[\frac{ma}{l}\right] = \frac{M\,LT^{-2}}{L} = ML^0T^{-2}$$

$$\boxed{[k] = ML^0T^{-2}}$$

And; $[b] = \left[\frac{ma}{k}\right] = \frac{[m][a]}{[k]} = \frac{M\,LT^{-2}}{ML^0T^{-2}} = L^1$

$\boxed{[b] = L}$ so; $\boxed{\text{Unit of 'b' = meter}}$ Ans.

Q) The velocity v of a particle at time t is given by $v = at + \frac{b}{t+c}$, where a, b and c are constants. The dimensions of a, b and c are respectively:

(a) LT^{-2}, L and T

(b) L^2, T and LT^2

(c) LT^2, LT and L

(d) L, LT and T^2

Ans. a

Solution:

$$v = at + \frac{b}{t+c}$$

From "t + c" ; $[t] = [c] \Rightarrow \boxed{[c] = T}$

And; $[v] = [at] = \left[\frac{b}{t+c}\right]$

so; $[at] = [v] \Rightarrow [a][t] = [v] \Rightarrow [a] = \frac{LT^{-1}}{T^{1}}$

$\boxed{[a] = LT^{-2}}$

$[v] = \left[\frac{b}{t+c}\right] \Rightarrow [v] = \frac{[b]}{[t]} \Rightarrow [b] = [v][t] = LT^{-1} \cdot T$

$\boxed{[b] = L}$

$\boxed{[a] = LT^{-2} ; \; [b] = L ; \; [c] = T}$ Ans

Q) The time dependence of physical quantity P is given by $P = P_0\, e^{-\alpha t^2 + \beta t + \gamma}$, where α, β, γ are constants and their dimensions are given by (where t is time) -

(a) $M^0 L^0 T^{-2}$, $M^0 L^0 T^{-1}$, $M^0 L^0 T^0$

(b) $M^0 L^{-1}, T^{-2}$, $M^0 L^0 T^{-1}$, $M^0 L^0 T$

(c) $M^0 L^0 T^{-1}$, $M L T^{-2}$, $M^0 L^0 T^{-1}$

(d) M, L, T, $M L T^0$, $M^0 L^0 T^0$

Ans. a

Solution:

$$P = P_0 e^{-\alpha t^2 + \beta t + \gamma}$$

as; e^x = dimensionless

$$[P] = [P_0]$$

and power of 'e' is $-\alpha t^2 + \beta t + \gamma$

so; $-\alpha t^2 + \beta t + \gamma$ = Dimensionless

so; $[\alpha t^2] = [\beta t] = [\gamma]$ = Dimensionless $= M^0 L^0 T^0$

so; $[\alpha][t^2] = M^0 L^0 T^0 \Rightarrow [\alpha] T^2 = M^0 L^0 T^0 \Rightarrow \boxed{[\alpha] = T^{-2}}$

And; $[\beta][t] = M^0 L^0 T^0 \Rightarrow [\beta] T = M^0 L^0 T^0 \Rightarrow \boxed{[\beta] = T^{-1}}$

And; $[\gamma] = M^0 L^0 T^0 \Rightarrow$ $\boxed{\gamma = \text{Dimensionless}}$ Ans.

Q) If A and B are two physical quantities having different dimensions then which of the following can’t denote a new physical quantity?

(a) $A + \frac{A^3}{B}$ (b) $\exp\left(-\frac{A}{B}\right)$ (c) AB^2 (d) $\frac{A}{B^4}$

Ans. b

Solution:

As; A & B have different Dimensions.

so; $\frac{A}{B}$ = will definately have Dimension.

so; in (b) $e^{-\left(\frac{A}{B}\right)}$; As power cannot have dimension, but $\left(\frac{A}{B}\right)$ has Dimension.

so; this expression can't denote a new physical quantity.

Q) A hypothetical experiment conducted to find Young's modulus $Y = \frac{T^x \tau \cos\theta}{l^3}$ where τ is torque, l is length and T is time period then find x. [Hint: Unit of Y is N/m^2 and Torque = Force × Perpendicular distance]

(a) 0

(b) 1

(c) -1

(d) 2

Ans. a

Solution:

as; unit of $Y = N/m^2$

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

& $\tau = F \cdot r_\perp \Rightarrow [\tau] = [F][r] \Rightarrow [\tau] = MLT^{-2} \cdot L$

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

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

& $\cos\theta$ = Dimension less ; $[T] = M^0L^0T^1$

so, $[Y] = \frac{[T]^x[\tau]}{[l]^3} \Rightarrow ML^{-1}T^{-2} = \frac{T^x\, ML^2T^{-2}}{L^3}$

$ML^{-1}T^{-2} = T^x\, ML^{-1}T^{-2}$

$x = 0$

Q) While printing a book a printer made certain mistakes in the following relation. Find the correct relation.
(y, A and x are in meter)

(a) $y = A \sin \omega\theta$

(b) $y = A \sin (\omega x + \theta)$

(c) $y = A \sin (\omega t + \theta)$

(d) $y = (A/x) \sin \omega t + \theta$

Ans. c

Solution:

(a) $y = A \sin \omega\theta$

as $\sin \omega t$ = Dimensionless

& $[y] = [A] = M^0 L^1 T^0$

Dimensionally correct

(b) $y = A \sin(\omega x + \theta)$

as $\sin(\omega x + \theta)$ = Dimensionless

& $[y] = [A] = M^0 L^1 T^0$

Dimensionally correct

(c) $y = A \sin(\omega t + \theta)$

as $\sin(\omega t + \theta)$ = Dimensionless

& $[y] = [A] = M^0 L^1 T^0$

Dimensionally correct

(d) $y = \frac{A}{x} \sin(\omega t + \theta)$

as $\sin(\omega t + \theta)$ = Dimensionless

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

& $\left[\frac{A}{x}\right] = \frac{[A]}{[x]} = \frac{L}{L} = L^0$

so; $[y] \neq \left[\frac{A}{x}\right]$

so, this expression is not dimensionally correct.

Q) $\int \frac{dt}{\sqrt{2at-t^2}} = a^x \ sin^{-1}\left[\frac{t}{a} - 1\right]$The value of x is

(a) 1

(b) -1

(c) 0

(d) 2

Ans. c

Solution:

$$\int \frac{dt}{\sqrt{2at - t^2}} = a^n \sin^{-1}\left[\frac{t}{a} - 1\right]$$

as; $\sin^{-1}\left(\frac{t}{a} - 1\right)$ = Dimensionless

dt = change in time ; $[dt] = M^0 L^0 T^1$

$[2at] = [t^2] \Rightarrow [a][t] = [t^2] \Rightarrow [a] = [t] \Rightarrow \boxed{[a] = M^0 L^0 T^1}$

& $\boxed{[2at] = [t^2] = M^0 L^0 T^2}$

so; $\left[\frac{dt}{\sqrt{2at - t^2}}\right] = [a]^n \Rightarrow \frac{[dt]}{[2at - t^2]^{1/2}} = [a]^n$

$$\frac{T}{[T^2]^{1/2}} = [T]^n \Rightarrow \frac{T}{T} = [T]^n$$

$\Rightarrow T^0 = [T]^n \Rightarrow \boxed{n = 0}$ Ans

Q) If force $F = \frac{Ke^{-br}}{r^2}$ varies with distance r. Then write the dimensions of K and b

(a) ML^3T^{-2} , L^{-1}

(b) $M^{-2}LT^{-3}$, L^{-1}

(c) $ML^{-2}T^3$, L^{-2}

(d) $M^{-2}L^{-3}T^2$, L^{-2}

Ans. a

Solution:

$$F = \frac{k e^{-br}}{r^2}$$

as; e^{-br} and br are dimensionless

$\Rightarrow [br] = [b][r] = M^0 L^0 T^0 \Rightarrow [b] L = M^0 L^0 T^0$

$$\boxed{[b] = M^0 L^{-1} T^0}$$

& $[F] = \frac{[k]}{[r^2]} \Rightarrow [k] = [F][r^2] = MLT^{-2} \cdot L^2$

$$\boxed{[k] = ML^3T^{-2}}$$ Ans

Q) Let x, y and z be three physical quantities having different dimensions. Which of the following mathematical operations must be meaningless?

(a) $\frac{x}{y} = z$

(b) $\frac{xy}{x+y} = z$

(c) $x^2 y^3 = z$

(d) $x^2 + y^3 = z$

Ans. b

Solution:

If x, y and z, all have different dimensions.

so; x, y & z can't be added and subtracted directly.

x^a & y^b & z^c may have same dimension

for expression (d) $x^2 + y^3 = z$ may or may not be correct

But (b) $\frac{xy}{x+y} = z$; x & y can't be added.

so, (b) $\frac{xy}{x+y} = z$ must be meaningless expression.

Ans

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Chalo Niklo