DPP – 3 (Unit & Dimension)

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Q 1. If velocity (V), force (F) and energy (E) are taken as fundamental units, then dimensional formula for mass will be

(a) $V^{-2}F^0E^2$
(b) V^0FE^2
(c) $VF^{-2}E^0$
(d) $V^{-2}F^0E$

Q 2. The speed of light (c), gravitational constant (G, Unit = N-m^2/kg^2) and Planck's constant (h, Unit = J-s) are taken as the fundamental units in a system. The dimensions of time in this new system should be

(a) $G^{\frac{1}{2}}h^{\frac{1}{2}}c^{\frac{-5}{2}}$
(b) $G^{-\frac{1}{2}}h^{\frac{1}{2}}c^{\frac{1}{2}}$
(c) $G^{\frac{1}{2}}h^{\frac{1}{2}}c^{-\frac{3}{2}}$
(d) $G^{\frac{1}{2}}h^{\frac{1}{2}}c^{\frac{1}{3}}$

Q 3. If the time period (T) of vibration of a liquid drop depends on surface tension (S, Unit = N/m), radius (r) of the drop and density (ρ) of the liquid, then the expression of T is: (k is dimensionless constant)

(a) $T = k\sqrt{\rho r^3/s}$
(b) $T = k\sqrt{\rho^{\frac{1}{2}}r^3/s}$
(c) $T = k\sqrt{\rho r^3/s^{\frac{1}{2}}}$
(d) None of these

Q 4. If the capacitance of a nanocapacitor (Unit = $coulamb^2/J$) is measured in terms of a unit 'u' made by combining the electric charge 'e', Bohr radius 'a_o', Planck's constant 'h' (Unit = J-s) and speed of light 'c' then

(a) $u = \frac{e^2h}{a_o}$
(b) $u = \frac{hc}{e^2a_o}$
(c) $u = \frac{e^2c}{ha_o}$
(d) $u = \frac{e^2a_o}{hc}$

Q 5. Pressure inside a gas container is P = 5 kPa. Its value in CGS system will be:

(a) $5 \times 10^{-6}\ dyn - cm^{-2}$
(b) $5 \times 10^4\ dyn - cm^{-2}$
(c) $10^6\ dyn - cm^{-2}$
(d) $5 \times 10^{-6}\ dyn - m^{-2}$

Q 6. What will be the value of momentum 1 kg-m/s in CGS system:

(a) 10^{-6} gm-cm/s
(b) 10^5 gm-cm/s
(c) 10^6 gm-cm/s
(d) 5×10^5 gm-cm/s

Q 7. A bicycle has a speed of 6 m/s. What is its speed in km/h?

(a) 21.6 km/h
(b) 16.67 km/h

(c) 2.16 km/h (d) 1.67 km/h

Q 8. The area of a room is 10 m^2 The same in $feet^2$ is:
Hint:- 1m=3.28ft
(a) 107.6 $feet^2$ (b) 77 $feet^2$
(c) 77.6 $feet^2$ (d) none of these

Q 9. What is the value of gravitational constant G in CGS system?
$(\boldsymbol{G} = 6.67 \times 10^{-11}\ N\,m^2/kg^2)$
(a) $6.674\times10^{-11}\ cm^3\cdot\mathbf{g}^{-1}\cdot s^{-2}$ (b) $6.674\times10^{-8}\ cm^3\cdot\mathbf{g}^{-1}\cdot s^{-2}$
(c) $6.674\times10^{-8}\ cm^3\cdot\mathbf{g}\cdot s^{-2}$ (d) $6.674\times10^{-8}\ cm^3\cdot\mathbf{g}^{-1}\cdot s^{-1}$

Q 10. If work done is $W = 20\ Joule$, then work done in CGS system will be:
(a) $2 \times 10^7\ erg$ (b) $20 \times 10^8\ erg$
(c) $2 \times 10^8\ erg$ (d) $10^8\ erg$

Q 11. If minute is the unit of time, 10 m/s^2 s the unit of acceleration and 100 kg is the unit of mass, then the value of one joule in new unit of work is:
(a) 10^6 new unit (b) $\frac{1}{10^6}$ new unit
(c) $\frac{1}{36\times10^6}$ new unit (d) 36×10^6 new unit

Q 12. Young's modulus of steel is $2 \times 10^{11} N/m^2$. Its numerical value in CGS unit will be
(a) 2×10^{12} (b) 2×10^{11}
(c) 4×10^{12} (d) 4×10^{11}

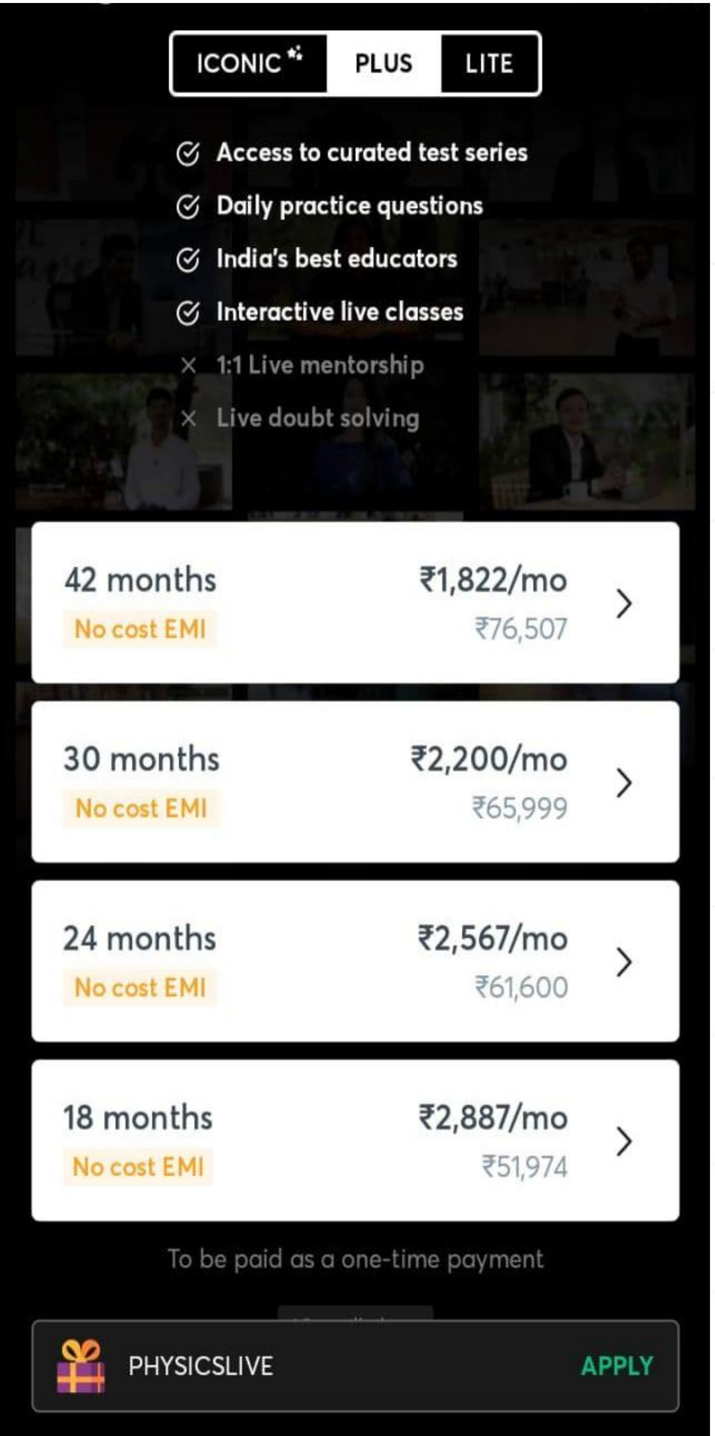
Q 13. The value of g is 9.8 m/s^2. Its value in a new system in which the unit of length in kilometer and that of time in minute, is:
(a) 35.3 km-minute^{-2} (b) 3.53 km-minute^{-2}
(c) 353 km-minute^{-2} (d) 0.353 km-minute^{-2}

Q 14. If unit of mass become 2 times, the unit of length becomes 4 times and the unit of time becomes 4 times in the unit of Plank's constant(J-s). Due to this, unit of plank's constant becomes n times. The value of n is
(a) 3 (b) 5
(c) 6 (d) 8

Q 15. In a new system of units, unit of mass is 10 kg, unit of length is 100 m, unit of time is 1 minutes. The magnitude of 1 N force in new system of units will be
(a) 36 (b) 60
(c) 3.6 (d) 0.06

Answer Key

Q.1 d	Q.2 a	Q.3 a	Q.4 d	Q.5 b
Q.6 b	Q.7 a	Q.8 a	Q.9 b	Q.10 c
Q.11 c	Q.12 a	Q.13 a	Q.14 d	Q.15 c



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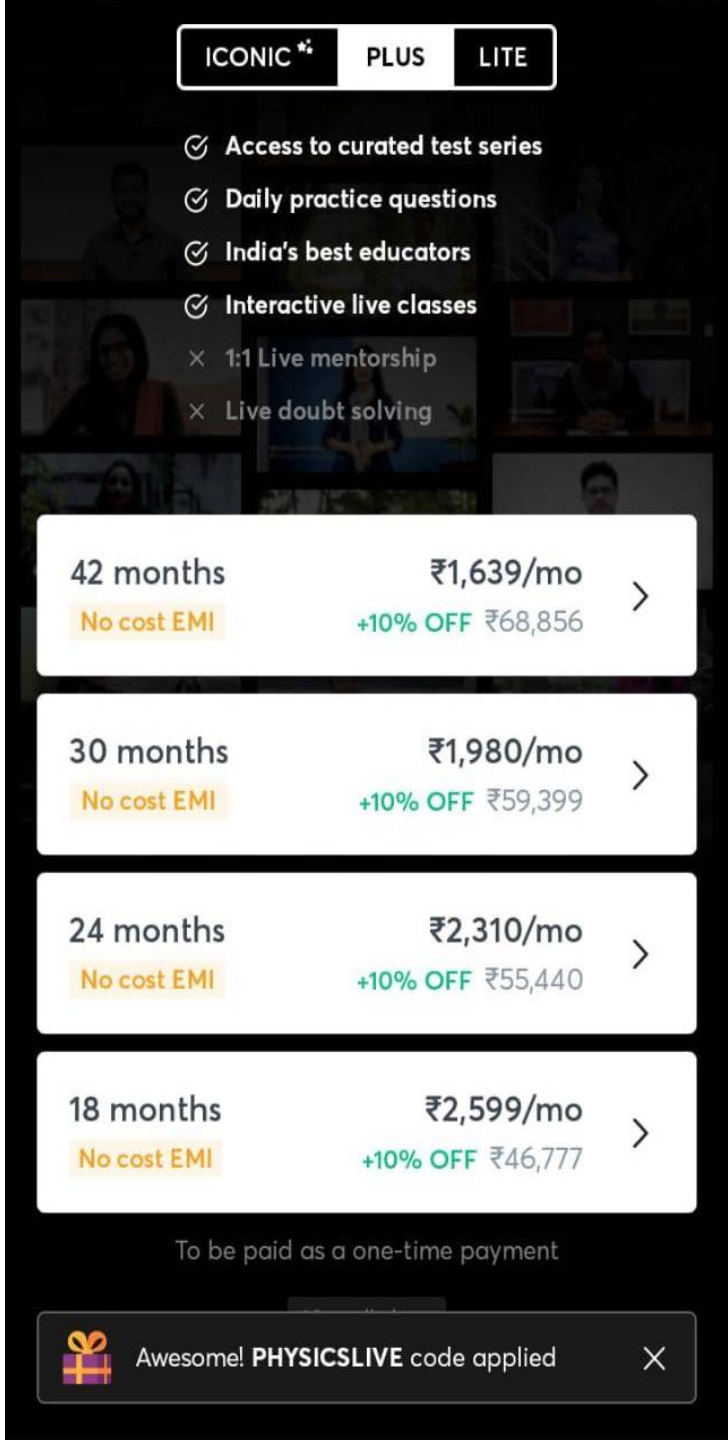

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Written Solution

DPP-3 deriving Physical relations and Unit Conversion

By Physicsaholics Team

method -1

Solution: 1

let $m \propto v^a F^b E^c$

Taking dimension in both side.

$M^1L^0T^0 = [LT^{-1}]^a [MLT^{-2}]^b [ML^2T^{-2}]^c$

Comparing Powers

for 'M' $1 = b + c$ — (1)

for 'L' $0 = a + b + 2c$ — (2)

for 'T' $0 = -a - 2b - 2c$ — (3)

$a = -2, \ b = 0, \ c = 1$

Method -2

$v, \ F, \ E$

$\text{Power} = \frac{E}{t} = Fv$

$F = ma = m\frac{v}{t}$

$\Rightarrow t = \frac{mv}{F}$

so; $\frac{E}{mv} F = Fv$

$m = \frac{E}{v^2}$

$m = E^1 v^{-2} F^0$ Ans

Ans. d

Solution: 2

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

$[G] = MLT^{-2} \times L^2 \times M^{-2} = M^{-1}L^3T^{-2}$

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

$[T] = [c]^x [G]^y [h]^z$

$[T] = [LT^{-1}]^x [M^{-1}L^3T^{-2}]^y [ML^2T^{-1}]^z \Rightarrow M^{-y+z} L^{x+3y+2z} T^{-x-2y-z}$

$M \Rightarrow 0 = -y + z \Rightarrow \boxed{y = z}$ — ①

$L \Rightarrow 0 = x + 3y + 2z \Rightarrow \boxed{x = -5y = -5z}$ — ②

$T \Rightarrow 1 = -x - 2y - z$

$\Rightarrow 1 = -x - 2\left(-\frac{x}{5}\right) - \left(-\frac{x}{5}\right)$

$1 = -x + \frac{2x}{5} + \frac{x}{5} = \frac{-2x}{5} \Rightarrow \boxed{x = -\frac{5}{2}}$; $\boxed{y = z = \frac{1}{2}}$

So;

$\boxed{[T] = G^{1/2} h^{1/2} c^{-5/2}}$ Ans

Ans. a

Solution: 3

M-1

Let $T \propto S^x r^y \rho^z$

$$T = K S^x r^y \rho^z$$

Taking dimension in both sides.

$$T = [MT^{-2}]^x [L]^y [ML^{-3}]^z$$

Comparing Powers.

for 'M' $\Rightarrow$ $0 = x + z$ — (1)

for 'L' $\Rightarrow$ $0 = y - 3z$ — (2)

for 'T' $\Rightarrow$ $1 = -2x$ — (3)

$$x = -\frac{1}{2}, \quad z = \frac{1}{2}, \quad y = \frac{3}{2}$$

$$T = K\sqrt{\frac{\rho r^3}{S}}$$

M-2

T, S, r, ρ

$$H = \frac{2S}{r\rho g}$$

dimension of $H = r$

so, Dimensionally:

$$r = \frac{S}{r\rho g}$$

$g = m/s^2$ (acceleration due to gravity)

Dimensionally; $g = r/T^2$

$$\text{so;} \quad r = \frac{S}{r\rho r} \times T^2$$

$$T^2 = \frac{\rho r^3}{S} \Rightarrow T = \sqrt{\frac{\rho r^3}{S}}$$

$$\boxed{T = K\sqrt{\frac{\rho r^3}{S}}}$$

Ans

Ans. a

Solution: 4

Method-1

let $u \propto e^x a_0^y h^z c^k$

Taking dimensions both side:

$M^{-1}L^{-2}T^{4}A^{2} = [AT]^x [L]^y [ML^2T^{-1}]^z [LT^{-1}]^k$

comparing power of M, L, T & A in both sides

for 'M' $\quad -1 = z \quad$ —(1)

for 'L' $\quad -2 = y + 2z + k \quad$ —(2)

for 'T' $\quad 4 = x - z - k \quad$ —(3)

for 'A' $\quad 2 = x \quad$ —(4)

$x = 2,\ y = 1,\ z = -1,\ k = -1$

Method-2

$E = \frac{hc}{\lambda} = \frac{q^2}{2u}$

dimensionally; $a_0 = \lambda$

so; $\frac{hc}{a_0} = \frac{e^2}{2u}$

$$u = \frac{e^2 a_0}{hc}$$ Ans.

Ans (d)

Solution: 5

$P = 5\ kPa$

$P = 5 \times 10^3\ N/m^2$

$1N = 10^5\ dyn$

$1m = 100\ cm$

So; P in CGS system

$$P = 5 \times 10^3 \times \frac{10^5\ dyn}{(100\ cm)^2}$$

$P = 5 \times 10^4\ dyn/cm^2$

Ans. b

Solution: 6

Momentum, $P = mv$

MKS/SI unit = kg-m/s

CGS unit = gm-cm/s

so; 1 kgm-m/s = 1 $\times 10^3$ gm $\times$ 100 cm/s

1 kg-m/s = 10^5 gm-cm/s

Ans. b

Solution: 7

$V = 6 \frac{m}{s}$

$1 \frac{m}{s} = \frac{1 \times 10^{-3} km}{\frac{1}{60\times60} hr}$

$\because 1 m = 10^{-3} km$

$1 sec = \frac{1}{60\times60} hr$

$\therefore 1 m/s = 10^{-3} \times 60 \times 60 \; km/hr$

$= \frac{60\times60}{1000} km/hr$

$= \frac{18}{5} km/hr$

So, $v = 6 \; m/s = 6 \times \frac{18}{5} km/hr$

$= 21.6 \; km/hr$

Ans. a

Solution: 8

$$Area = 10\,m^2$$

$$1\,m = 3.28\,ft$$

$$(1\,m)^2 = (3.28\,ft)^2$$

$$1\,m^2 = (3.28)^2\,ft$$

$$Area = 10\,m^2 = 10 \times 1\,m^2$$

$$= 10 \times (3.28)^2\,ft^2$$

$$= 107.6\,ft^2$$

Ans. a

Solution: 9

$$G = 6.67 \times 10^{-11}\ N\,m^2/kg^2$$

$$= 6.67 \times 10^{-11}\ m^3/kg\text{-}s^2$$

$$= 6.67 \times 10^{-11}\ (100\,cm)^3/(1000\,g)\text{-}s^2$$

$$= 6.67 \times 10^{-11} \times \frac{10^6}{10^3}\ cm^3/g\text{-}s^2$$

$$= 6.67 \times 10^{-8}\ cm^3 g^{-1} s^{-2}$$

Ans. b

Solution: 10

$W = 20$ Joule

$= 20$ N-m

$= 20$ kg m^2/s^2

$= 20\ (1000\text{gm})(100\text{cm})^2/s^2$

$= 20 \times 10^3 \times 10^4$ gm cm^2/s^2

$= 2 \times 10^8$ gm cm^2/s^2

$= 2 \times 10^8$ erg

Ans. c

Solution: 11 Dimensions of work [J] = ML^2T^{-2}

Dimensions of acceleration [a] = LT^{-2}

so; dimensions of length in terms of 'a' & 'T'

Dimensionally; $a = LT^{-2} \Rightarrow L = aT^2$

so; Dimensions of work (J) in terms of acceleration $= ML^2T^{-2} = M[aT^2]^2T^{-2}$

$= Ma^2T^2$

let; 1 J = n_2 new unit

$n_1u_1 = n_2u_2$

$1 \times [M_1a_1^2T_1^2] = n_2[M_2a_2^2T_2^2]$

$$n_2 = \left[\frac{M_1}{M_2}\right]\left[\frac{a_1}{a_2}\right]^2\left[\frac{T_1}{T_2}\right]^2$$

$$n_2 = \left[\frac{kg}{100\,kg}\right]\left[\frac{1\ m/s^2}{10\ m/s^2}\right]^2\left[\frac{1\ sec}{1\ minute}\right]^2$$

$$= \frac{1}{100}\times\left[\frac{1}{10}\right]^2\left[\frac{1\ sec}{60\ sec}\right]^2$$

$$= \frac{1}{100}\times\frac{1}{100}\times\left(\frac{1}{60}\right)^2 = \frac{1}{10^4}\times\frac{1}{3600} = \frac{1}{36\times10^6}$$

$$n_2 = \frac{1}{36\times10^6}$$

So;

$$1\ J = \frac{1}{36\times10^6}\ \text{New Unit}$$

Ans: (1)

Solution: 12

$$Y = 2\times10^{11}\ N/m^2$$

$$n_1u_1 = n_2u_2$$

$$2\times10^{11}\ (N\cdot m^{-2}) = n_2\ (dyne\cdot cm^{-2})$$

$$n_2 = 2\times10^{11}\left(\frac{N}{dyne}\cdot\frac{m^{-2}}{cm^{-2}}\right)$$

$$= 2\times10^{11}\left(\frac{10^5\ dyne}{dyne}\cdot\frac{100^{-2}\ cm^{-2}}{cm^{-2}}\right)$$

$$= 2\times10^{11}\times10^5\times10^{-4}$$

$$\boxed{n_2 = 2\times10^{12}}\ \text{Ans}$$

Ans. a

Solution: 13

$$n_1 u_1 = n_2 u_2$$

$$9.8 \ m \cdot s^{-2} = n_2 (km \cdot minute^{-2})$$

$$n_2 = 9.8 \times \left(\frac{m}{km}\right) \cdot \left(\frac{sec}{min}\right)^{-2}$$

$$= 9.8 \left(\frac{m}{10^3 m}\right) \times \left(\frac{sec}{60 sec}\right)^{-2}$$

$$= 9.8 \left(\frac{1}{10^3} \times \frac{1}{(60)^{-2}}\right) = 9 \times 10^8 \times \left(10^{-3} \times (60)^2\right)$$

$$= 9.8 \times 10^{-3} \times 36 \times 10^2$$

$$= 35.3 \times 10^{-1}$$

$$n_2 = 35.3 \ km \cdot min^{-2}$$ Ans

Ans. a

Solution: 14

Unit of Planks constant = J-S = N-m-S

$= kg\text{-}\frac{m}{s^2} \times m \times s$

$= kg\text{-}m^2/s$

so; in old system $u_1 = kg\text{-}m^2/s$

In new system; $u_2 = (2\,kg)\cdot(4\,m)^2/(4\,s)$

$= 2 \times \frac{4^2}{4}\; kg \cdot m^2/s$

$u_2 = 8\; kg \cdot m^2/s$

$$\boxed{u_2 = 8\,u_1}$$

Ans. d

Solution: 15

$$1\,N = 1\ kg\text{-}m/s^2$$

$$n_1 u_1 = n_2 u_2$$

$$1 \times kg\text{-}m \cdot s^{-2} = n_2 \times (10kg) \cdot (100m) \cdot (min)^{-2}$$

$$n_2 = \frac{kg}{10kg} \cdot \left(\frac{m}{100m}\right) \cdot \left(\frac{s}{60 sec}\right)^{-2}$$

$$= \frac{1}{10} \cdot \frac{1}{100} \cdot \frac{1}{60^{-2}} = 10 \times \frac{1}{10^2} \cdot 60^2$$

$$= \frac{1}{1000} \times 3600$$

$$\boxed{n_2 = 3.6}$$ Ans.

Ans. C

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