Damanhour University

Faculty of Engineering Damanhour University

Preparatory Year	Physics (1)	2023-2024

Sheet (1):- Units & Dimensions

1. The cgs equivalent of (0.02 pa.s) dynamic coefficient of viscosity is

$$0.02\ Pa.s = 0.02\ \frac{N.s}{m^2}$$

$$= 0.02 * \frac{10^5 * 1}{(10^2)^2} = 0.2\ dyne.s/cm^2 \rightarrow \boxed{c}$$

2. The cgs equivalent of a (0.01 N/m) surface tension coefficient is

$$0.01\ \frac{N}{m} = 0.01 * \frac{Kg.\cancel{m}}{s^2.\cancel{m}} = 0.01 * \frac{10^3}{(1)^2} = 10\ g/s^2 \rightarrow \boxed{b}$$

3. Dimension of angular velocity is

$$\omega = \frac{\theta}{t} = \frac{rad}{s} = s^{-1} \Rightarrow [T^{-1}] \rightarrow \boxed{d}$$

4. The SI equivalent of a(10^8 erg) work is

$$10^8\ erg \div 10^7 = 10\ Joul = 10\ Kg.m^2/s^2 \rightarrow \boxed{b}$$

5. The cgs equivalent of a(10 m/min^2) linear acceleration is

$$10\ \frac{m}{(min)^2} = 10\ \frac{100}{(60)^2} = 0.277\ cm/s^2 = 0.28\ cm/s^2 \rightarrow \boxed{d}$$

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6. It's known that the the volume flowrate (Q) of a viscous fluid inside a capillary tube depends on the tube's radius (r) and length (L), the pressure difference between its end (Δ p) and the fluid's dynamic viscosity (μ) which has a dimensions of $ML^{-1}T^{-1}$. Based on that ,the following equation:

$$Q = \frac{\pi \Delta p r^4}{8 \mu L^2}$$

$LHS = Q = \frac{\text{volume}}{\text{time}} \Rightarrow \frac{m^3}{s} \Rightarrow [LHS] = [L^3 T^{-1}]$

$RHS = \frac{N \cdot \cancel{m^4} \cdot m \cdot s}{\cancel{m^2} \cdot \cancel{m^2} \cdot Kg} \Rightarrow \frac{[\cancel{M}LT^{-2}]}{[\cancel{M}L^{-1}T^{-1}]} = [RHS]$

$[L^2 T^{-1}]$

$[RHS] \neq [LHS] \rightarrow$ The equation is wrong $\rightarrow \boxed{b}$

7. The period (T) of a simple pendulum is given by the equation : where (l)is the length of pendulum and (g) is the free-fall acceleration . This equation is $T = 2\pi\sqrt{\frac{l}{g}}$

$LHS = T \Rightarrow [LHS] = [T]$

$[RHS] = \sqrt{\frac{[\cancel{L}]}{[\cancel{L}T^{-2}]}} = \sqrt{\frac{1}{T^{-2}}} = [\sqrt{T^2}] = [T]$

$[LHS] = [RHS]$

The equation is dimensionally correct $\rightarrow \boxed{c}$

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8. The velocity (v) of transverse wave in a rope depend on the tensile force (F) and the rope's mass per unit length (μ=m/L) .Using dimensional analysis prove that

$V \propto F, \mu$

$\boxed{V = C F^{\alpha} \mu^{B}} \rightarrow ①$

$[LT^{-1}] = [MLT^{-2}]^{\alpha} \cdot [ML^{-1}]^{B}$

M → $0.0 = \alpha + B$

L → $1 = \alpha - B$

T → $-1 = -2\alpha \Rightarrow \boxed{\alpha = \frac{1}{2}}, \boxed{B = -\frac{1}{2}}$

Subin ① by $\alpha = \frac{1}{2}, B = -\frac{1}{2}$

$\boxed{V = C\sqrt{\frac{F}{\mu}}} \rightarrow \boxed{d}$

9. Using of dimensional analysis ,the dependency of the speed (V) of transmitted sound in a fluid on the fluid's density (ρ) and bulk modulus (B) can be derived as

(Hint : B has the same dimension as apressure)

$V \propto \rho, B$

$\boxed{V = C \rho^{\alpha} B^{\beta}} \rightarrow ①$

$[LT^{-1}] = [ML^{-3}]^{\alpha} [ML^{-1}T^{-2}]^{B}$

M → $0.0 = \alpha + B$

L → $1 = -3\alpha - B$

T → $-1 = -2B \Rightarrow \boxed{B = \frac{1}{2}}, \boxed{\alpha = -\frac{1}{2}}$

Sub in 1 by $\alpha = -\frac{1}{2}$, $\beta = \frac{1}{2}$

$\boxed{V = C\sqrt{\frac{B}{\rho}}} \rightarrow \boxed{b}$

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10. frequency (f) of a transverse wave in a string depends on the tensile (F),the string's length (L) and it's mass per unit length (μ=m/L) . Using dimensional analysis prove that

$f \alpha F, L, \mu$

$f = C F^{\alpha} L^{B} \mu^{\gamma}$

$[T^{-1}] = [MLT^{-2}]^{\alpha} [L]^{B} [ML^{-1}]^{\gamma}$

$M \rightarrow 0.0 = \alpha + \gamma$

$L \rightarrow 0.0 = \alpha + B - \gamma$

$T \rightarrow -1 = -2\alpha \Rightarrow \boxed{\alpha = \tfrac{1}{2},\ \gamma = -\tfrac{1}{2},\ B = -1}$

$f = C F^{1/2} L^{-1} \mu^{-1/2}$

$f = \frac{C}{L} \sqrt{\frac{F}{\mu}}$ $\quad f \alpha L^{-1}$

$\rightarrow$ a

11. In the pervious problem if f =1 Hz results when μ=0.25 kg/m , L=1m and F=1N , the proportionality constant of the relationship is

$f = \frac{C}{L} \sqrt{\frac{F}{\mu}}$

$C = f \cdot L \sqrt{\frac{\mu}{F}}$

$C = 1 * 1 \sqrt{\frac{0.25}{1}} \Rightarrow \boxed{C = 0.5}$

$\rightarrow$ B

12. Using dimensional analysis the viberational period (T)from a droplet can be derived in terms of the droplets radius (r), its surface tension coefficient (s) and density (ρ)

(Hint : S has dimension of MT^{-2})

$T \propto r, s, \rho$

$T = C\, r^{\alpha} s^{\beta} \rho^{\gamma}$

$[T] = [L]^{\alpha} [MT^{-2}]^{\beta} [ML^{-3}]^{\gamma}$

$S = \frac{F}{m} = \frac{MLT^{-2}}{L} = [MT^{-2}]$

$M \Rightarrow 0.0 = \beta + \gamma \quad \boxed{\gamma = \frac{1}{2}}$

$L \Rightarrow 0.0 = \alpha - 3\gamma \quad \boxed{\alpha = \frac{3}{2}}$

$T \Rightarrow 1 = -2\beta \Rightarrow \boxed{\beta = -\frac{1}{2}}$

$T = C\, r^{3/2} s^{-1/2} \rho^{1/2}$

$T = C\sqrt{\frac{r^3 \rho}{S}} \Rightarrow T \propto \rho^{0.5}$

$\boxed{b}$

13. The frictional force (F) that arises between adjacent layers of afulid is known to depend on velocity gradient (dv/dy) of the flow , the joint area (A) between the layers and the dynamic viscocity (η).

$\eta = Pa.s = \frac{N}{m^2}.s = \frac{MLT^{-2}}{L^2}.s = [ML^{-1}T^{-1}]$

$F \propto \frac{dv}{dy}, A, \eta$

$[F] = C \cdot [\frac{dv}{dy}]^{\alpha} [A]^{\beta} [\eta]^{\gamma}$

$[MLT^{-2}] = [T^{-1}]^{\alpha} [L^2]^{\beta} [ML^{-1}T^{-1}]^{\gamma}$

$M \Rightarrow 1 = \gamma$

$L \Rightarrow 1 = 2\beta - \gamma \Rightarrow \boxed{\beta = 1}$

$T \Rightarrow -2 = -\alpha - \gamma \Rightarrow \alpha = 1$

$\boxed{F = C \frac{dv}{dy} A \eta}$

$F \propto A \quad F \propto \eta$

$F \propto \frac{dv}{dy}$

Halving A halves F

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لو A قلت لنصف الـ F هتقل لنصف (تناسب طردي)

$\boxed{d}$

13. The following equations :- $v=\sqrt{\frac{3k_BT}{m}}$ defines the velocity (v) of a gas molecules in term of its mass (m) absolute temperature (T) and Boltzmann's constant (k_B) . physical dimension of(k_B) is

$$V=\sqrt{\frac{3K_B \cdot T}{m}} \Rightarrow \boxed{\frac{V^2 \cdot m}{3T} = K_B}$$

$$[K_B] = \frac{[L^2T^{-2}][M]}{[K]}$$

$$= [M L^2 T^{-2} K^{-1}]$$

$\to \boxed{a}$

14. in previous problem ,the cgs unit of k_B is

$$[M L^2 T^{-2} K^{-1}] \to g\, cm^2 s^{-2} C^{-1}$$

$\boxed{erg / °C}$

$2 \to \boxed{c}$

note

$\boxed{1 J \to 10^7 erg = 10^7 g\, cm^2 s^{-2}}$

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15. The amount of heat transfer (Q) to an object of mass (m) as its temperature increase from T_1 to T_2 is given by: $Q=m\,c\,(T_2-T_1)$, where (c) is the specific heat of the object's material . The dimensions of (c)is

$$Q = m\,c\,(T_2 - T_1)$$

$$c = \frac{Q}{m(T_2-T_1)} = \frac{J}{Kg \cdot K} = \frac{N \cdot m}{Kg \cdot K}$$

$$[c] = \frac{[MLT^{-2}][L]}{[M][K]} = [L^2 T^{-2} K^{-1}]$$

$\hookrightarrow \boxed{a}$

16. An ideal fluid of mass (m) and density (ρ)flows inside a capillary tube with cross sectional area (A) with constant velocity (v) .Within a time interval (Δ t) , the following equation :$\mathbf{m^2 = \rho\, v\, A\, \Delta t}$

$$[LHS] = [m^2] = [M^2]$$

$$[RHS] \Rightarrow [M\cancel{L^{-3}}][\cancel{L}\cancel{T^{-1}}][\cancel{L^2}][\cancel{T}]$$

$$RHS = [M]$$

$$[LHS] \neq [RHS]$$

$\therefore$ The equation is wrong

$\hookrightarrow \boxed{b}$

17. The electrical power is defined as the product of the electric current and the electric potential difference thus the dimensions of the electric potential difference is

$P = I\,\Delta V$, $P = \frac{W \rightarrow \text{energy (J)}}{t \rightarrow \text{Time (s)}}$

$\Delta V = \frac{P}{I} \Rightarrow \frac{[ML^2T^{-2}]}{[T][A]}$

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

$\rightarrow \boxed{d}$

18. The electric potential difference is defined as the product of the electric current and the ohmic resistance . Thus the SI unit of the ohmic resistance

$\Delta V = I \cdot R$ (ohm's Law)

$R = \frac{\Delta V}{I}$

$[R] = \frac{[ML^2T^{-3}A^{-1}]}{[A]}$

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

$(Kg\,m^2/s^3 A^2) \rightarrow$ SI Unit

$\rightarrow \boxed{b}$

19. The electrostatic force (F) between two point charges (q_1) and (q_2) separated by a distance (r) is given in terms coulombs constant (k)by the equation : **F=k** $\frac{q_1 q_2}{r^2}$, based on that , the dimensions of (k) is

$$F = K \frac{q_1 q_2}{r^2}$$

Electric charge $(q) = I * t$

Current Time

$[q] = [AT]$

$$K = \frac{F * r^2}{q^2}$$

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

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

$\hookrightarrow \boxed{c}$

20. The cgs value of a (35 W/m².k) thermal convection coefficient is

$$35 \frac{W}{m^2.K} = 35 \frac{J}{s\, m^2.K}$$

$$= 35 * \frac{10^7}{1*(10^2)^2.1}$$

$$= 35 * 10^3 \ erg/cm^2.s.K \ \underline{\underline{or}} \ erg/cm^2.s\,^\circ C$$

$$= \boxed{35000 \ erg/cm^2.s.^\circ C}$$

$\hookrightarrow \boxed{b}$

 Note $\Delta\theta_{\text{in Kelvin}} = \Delta\theta_{\text{in Celsius}}$