JEE Paper -2022

PHYSICS

1. Find radius ratio of proton, deuteron and alpha particle the same magnetic field having equal kinetic energy

(1) $1:1:\sqrt{2}$

(2) $1:\sqrt{2}:1$

(3) $1:2:\sqrt{2}$

(4) $\sqrt{2}:1:2$

Sol. Answer (2)

Given $K_p = K_d = K_\alpha$

$$r = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2mK}}{qB}$$

$$r \propto \frac{\sqrt{m}}{q}$$

$$r_p : r_d : r_\alpha = \frac{\sqrt{m_p}}{q_p} : \frac{\sqrt{m_d}}{q_d} : \frac{\sqrt{m_\alpha}}{q_\alpha}$$

$q_p = e$ $\quad$ $m_p = m$

$q_d = e$ $\quad$ $m_d = 2m$

$q_\alpha = 2e$ $\quad$ $m_\alpha = 4m$

$$r_p : r_d : r_\alpha = \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e}$$

$$= 1:\sqrt{2}:1$$

2. Two travelling wave length opposite direction $y = 10\cos(\pi x)\sin\left(\frac{2\pi t}{T}\right)$ amplitude at $x = \frac{4}{3}$m

(1) 5 $\quad$ (2) 10

(3) 12 $\quad$ (4) 11

Sol. Answer (1)

Given equation of standing wave is $y = 10\cos(\pi x)\sin\left(\frac{2\pi t}{T}\right)$

Amplitude = $10\cos(\pi x)$

$$= 10\cos\left(\frac{4}{3}\pi\right)$$

$$= 10\cos\left(\pi + \frac{\pi}{3}\right) = -10\cos\frac{\pi}{3}$$

$$= -10 \times \frac{1}{2} = -5$$

Amplitude = |–5| = 5

Remark : Amplitude is the distance of extreme position from mean position.

General equation of standing equation

$$y = (2A\cos kx)\sin wt$$

3. A particle of mass 5 kg is projected vertically upward with velocity 20 m/s. If air resistance for motion is 10 N. Ratio of time of ascent to that of time of descent, is

(1) $\sqrt{2}:\sqrt{3}$ $\quad$ (2) $\sqrt{3}:\sqrt{2}$

(3) 2 : 3 $\quad$ (4) 3 : 2

Sol. Answer (1)

Given, m = 5 kg, u = 20 m/s, F_{drag} = 10 N

During ascent :

$$a = -\left(g + \frac{10}{5}\right)\hat{j}$$

$$a = -(12)\hat{j}$$

During descent :

$$a = -g\hat{j} + \frac{10}{5}\hat{j}$$

$$a = (-8)\hat{j}$$

$$d_{upwards} = d_{downwards}$$

$$\frac{1}{2}(12)(t_{up})^2 = \frac{1}{2}(8)(t_{down})^2$$

$$\frac{t_{up}}{t_{down}} = \frac{\sqrt{2}}{\sqrt{3}}$$

4. A mass m suspended with the help of string is moving in vertical circular motion. The tension in the string is

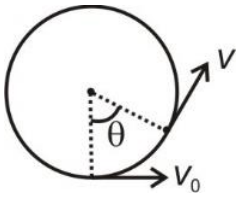
(1) Same throughout

(2) Maximum at top

(3) Minimum at top

(4) Maximum at horizontal level

Sol. Answer (3)



Velocity at any angular position θ is v

$$\frac{1}{2}mv_0^2 - mgR = \frac{1}{2}mv^2 - mgR\cos\theta$$

$$v^2 = v_0^2 - 2gR(1-\cos\theta)$$

$$T - mg\cos\theta = \frac{mv^2}{R}$$

$$T - mg\cos\theta = \frac{m}{R}[v_0^2 - 2gR(1-\cos\theta)]$$

$$T = \frac{mv_0^2}{R} + mg\cos\theta - 2mg(1-\cos\theta)$$

$$T = \frac{mv_0^2}{R} + 3mg\cos\theta - 2mg$$

as θ increases, tension decrease

so, at top T is minimum

5. Parallel plate capacitor charged to 60 mC plate discharges at 1.8×10^{-8} C/s. Magnitude of displacement current is

(1) 1.8×10^{-8} C/s (2) 3.6×10^{-8} C/s

(3) 5×10^{-8} C/s (4) 6×10^{-8} C/s

Sol. Answer (1)

Conduction current = displacement current

$$I_d = \frac{dQ}{dt}$$

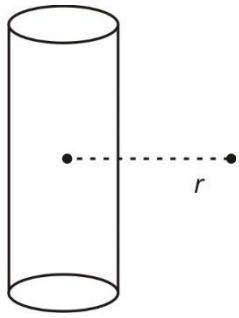
$$I_d = 1.8 \times 10^{-8} \text{ C/s}$$

6. A charged particle ($-q$, m) revolves around a cylinder of charge density ρ and radius R. The kinetic energy of particle is

(1) $\frac{\rho R^2 q}{4\epsilon_0}$ (2) $\frac{\rho R^2 q}{2\epsilon_0}$

(3) $\frac{\rho R^2 q}{8\epsilon_0}$ (4) $\frac{\rho R^2 q}{16\epsilon_0}$

Sol. Answer (1)



$$E = \frac{\lambda}{2\pi\epsilon_0 \times r}$$

$$= \frac{\rho \times \pi R^2 \times \ell}{2\pi\epsilon_0\, r \times \ell} = \frac{\rho R^2}{2\pi\epsilon_0\, r}$$

$$\therefore K.E = \frac{1}{2}mv^2$$

$$= \frac{1}{2}\left(\frac{mv^2}{r}\right) \times r$$

$$= \frac{1}{2}\left(q \times \frac{\rho R^2}{2\epsilon_0\, r}\right) \times r$$

$$= \frac{\rho R^2 q}{4\epsilon_0}$$

7. The ratio of intensities are $\frac{9}{4}$, then ratio of maximum to minimum intensity, is

(1) 20 : 1 (2) 25 : 1

(3) 16 : 1 (4) 64 : 1

Sol. Answer (2)

$$\frac{I_1}{I_2} = \frac{9}{4}$$

$$\Rightarrow \frac{A_1}{A_2} = \frac{3}{2} \text{ or } \frac{A_1 + A_2}{A_1 - A_2} = \frac{5}{1}$$

$$\frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \frac{25}{1}$$

8. Potential energy of two atom is $U = \frac{A}{r^{10}} - \frac{B}{r^5}$, find r for which potential energy is minimum.

(1) $2\left(\frac{A}{B}\right)^{\frac{1}{5}}$ (2) $\left(\frac{A}{B}\right)^{\frac{1}{5}}$

(3) $\left(\frac{2A}{B}\right)^{\frac{1}{5}}$ (4) $\left(\frac{A}{2B}\right)^{\frac{1}{5}}$

Sol. Answer (3)

Given : $U = \frac{A}{r^{10}} - \frac{B}{r^5}$

Potential energy is minimum when the separation between two atoms is such that they are in stable equilibrium

condition of stable equilibrium : $F_c = -\frac{dU}{dr} = 0$

$U \to U_{\min}$

$\frac{d^2U}{dr^2} > 0$

$U = \frac{A}{r^{10}} - \frac{B}{r^5}$

$\frac{dU}{dr} = -\frac{10A}{r^{11}} + \frac{B(5)}{r^6} = 0$

$= \frac{10A}{r^{11}} = \frac{B5}{r^6}$

$= \frac{2A}{B} = \frac{r^{11}}{r^6}$

$r^5 = \frac{2A}{B}$

$r = \left(\frac{2A}{B}\right)^{\frac{1}{5}}$

also check that

$\left.\frac{d^2U}{dr^2}\right|_{r=\left(\frac{2A}{B}\right)^{\frac{1}{5}}} > 0$

9. Two point charged particles with equal charge Q 10^{-5} C are kept on a table top. The particles have mass m = 10 gm and coefficient of friction between particle and table is 0.25. If particle are held at equilibrium so then l is equal to its minimum value then l is

(1) 2 m (2) 6 m

(3) 10 m (4) 21 m

Sol. Answer (2)

$\frac{1}{4\pi \epsilon_0}\frac{q^2}{l^2} = \mu mg$

$l^2 = \frac{1}{4\pi \epsilon_0}\frac{q^2}{\mu mg}$

$l^2 = \frac{9\times10^9 \times 10^{-10}}{0.25 \times \frac{10}{1000} \times 10}$

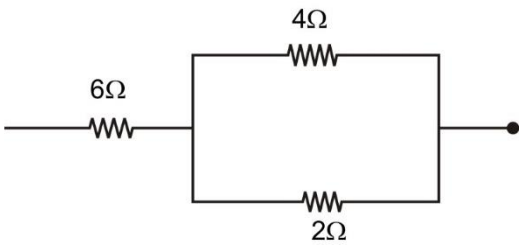
$l^2 = \frac{9\times10^{-1}}{\frac{25}{1000}}$

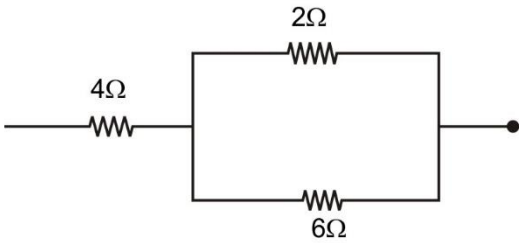
$l^2 = \frac{900}{25}$

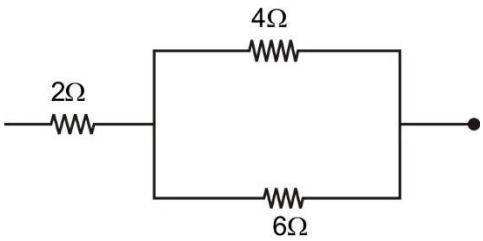
$l = \frac{30}{5}$

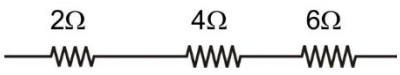
$l = 6$ m

10. For which combination of 2 Ω , 4 Ω , 6 Ω resistance equivalent resistance is 22/3 Ω

(1) 

(2) 

(3) 

(4) 

Sol. Answer (1)

4Ω and 2Ω are in parallel

$\frac{4\times2}{4+2} = \frac{8}{6} = \frac{4}{3}\Omega$

$R_{eq} = \frac{4}{3}\Omega + 6\Omega = \frac{22}{3}\Omega$

11. 1.5 kg hammer strikes the nail of mas 100 gm with speed of 60 m/sec. If heat given to nail is 1/4th of energy of hammer. Find change in temperature of nail (S_{nail} = 2250 J/kg ºC)

(1) 1.5º C (2) 2º C

(3) 2.5º C (4) 3º C

Sol. Answer (4)

Kinetic energy of hammer is

$$K = \frac{1}{2}mv^2$$

Heat given to the nail

$$Q = \frac{K}{4}$$

$$Q = \frac{1}{8}mv^2$$

$$ms\Delta T = \frac{1}{8}mv^2$$

$$\frac{100}{1000} \times 2250 \times \Delta T = \frac{1}{8} \times 1.5 \times 60 \times 60$$

$$225\Delta T = \frac{1.5 \times 60 \times 60}{8}$$

$$\Delta T = \frac{1.5 \times 60 \times 60}{225 \times 8}$$

$$\Delta T = 3^{o}\text{ C}$$

12. A bulb of power rating 200W has efficiency of 3.5%. What is the peak value of magnetic field at a distance of 4m?

(1) $7.5 \times 10^{-8} T$ (2) $1.1 \times 10^{-8} T$

(3) $1.5 \times 10^{-8} T$ (4) $1.7 \times 10^{-8} T$

Sol. Answer (4)

Emitted power of bulb is

$$P_0 = P_i \times \frac{3.5}{100} = \frac{35P}{1000}$$

$$= \frac{35 \times 200}{1000} = 7\text{W}$$

Intensity at 4m is

$$\text{I} = \frac{P_0}{4\pi r^2} = \frac{7}{4\pi \times 4^2}$$

$$\text{I} = \frac{7}{64\pi}$$

$$\text{I} = \frac{B_0^2}{2\mu_0} C$$

$$B_0^2 = 2\mu_0 \text{ I/C}$$

$$B_0 = \sqrt{2\mu_0 \frac{\text{I}}{C}}$$

$$B_0 = \sqrt{\frac{2 \times 4\pi \times 10^{-7} \times 7}{64\pi \times 3 \times 10^8}}$$

$$B_0 = \sqrt{\frac{7}{24} \times 10^{-15}}$$

$$B_0 = \sqrt{\frac{7}{24}} \times 10^{-8}$$

$$B_0 = 1.7 \times 10^{-8}\ T$$

13. Two massless spring with spring constant 2 k and 9 k having 50 g and 100 g attached at free end, both have same v_{max}. Then find ratio of amplitude of vibrations

(1) 2 : 3 (2) 1 : 2

(3) 3 : 2 (4) 2 : 1

Sol. Answer (3)

$$v_{\max} = A\omega = A\sqrt{\frac{k}{m}}$$

$$\frac{(v_{\max})_1}{(v_{\max})_2} = \frac{A_1}{A_2}\sqrt{\frac{k_1}{k_2}}\sqrt{\frac{m_2}{m_1}}$$

$$\frac{1}{1} = \frac{A_1}{A_2}\sqrt{\frac{2k}{9k}}\sqrt{\frac{100}{50}}$$

$$\frac{A_1}{A_2}\sqrt{\frac{4}{9}} = 1$$

$$\frac{A_1}{A_2} = \frac{3}{2}$$

14. **Statement 1** : An AC circuit can be created with *O* reactance

Statement 2 : An AC circuit without power is not possible

(1) *A* (2) *B*

(3) *C* (4) *D*

Sol. Answer (3)

AC circuit can have zero reactance at resonance

$$X_L = X_C$$

$$X = X_L - X_C = 0$$

Statement 1 is true

If AC circuit is power reactive (resistance is zero),

Power factor of the circuit,

(like purely inductive / capacitive circuit connected to AC)

$$\cos\phi = 0$$

$$P = 0$$

Statement 2 is false

15. It is given that a flywheel starting from rest covers 5 rad in first second. Then the angle covered in next second is (consider constant angular acceleration)

(1) 10 rad

(2) 15 rad

(3) 20 rad

(4) 25 rad

Sol. Answer (2)

$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$

$5 = \omega_0 \times 1 + \frac{1}{2} \alpha \times l^2$

$5 = \omega_0 + \frac{1}{2} \alpha$

Given $\omega_0 = 0$

So, $\alpha = 10$ rad/s^2

$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$

$5 + \Delta\theta = 0 + \frac{1}{2} \times 10 \times 2^2$

$5 + \Delta\theta = 20$

$\Delta\theta = 15$ rad

Angle covered in next second

Option (2)

16. A coil of 1000 ternus and area 1 m^2 is rotated about its diameter with constant angular velocity of 1 rotation per sec in a uniform and perpendicular magnetic field of 0.07 Tesla. The maximum emf induced in the coil approximately is

(1) 200 Volts

(2) 400 Volts

(3) 220 Volts

(4) 440 Volts

Sol. Answer (4)

$\omega = 2\pi$ rad/s

$\phi = B\, nA\cos\omega t$

$\varepsilon_{ind} = -\frac{d\phi}{dt}$

$\varepsilon = nBA\omega\sin\omega t$

$\varepsilon_{max} = nBA\omega$

$\varepsilon_{max} = 1000 \times 0.07 \times 1 \times 2\pi$

$\varepsilon_{max} = 140\pi = 140 \times \frac{22}{7}$

= 440 volts

Option (4)

17. Ratio of masses initially in radioactive substance is 2:1. Total mass of substance is 10^{-2} kg. Half-lives of A and B is 4 sec & 8 Sec respectively. Find the ration of decayed mass after 16 sec.

(1) $\frac{11}{4}$

(2) $\frac{8}{3}$

(3) $\frac{5}{2}$

(4) $\frac{9}{5}$

Sol. Answer (3)

$\frac{MA_\circ}{MB_\circ} = \frac{2}{1} \Rightarrow \frac{NA_\circ}{NB^\circ} = \frac{2}{1}$

$\frac{(ty_2)_A}{(ty_2)_B} = \frac{4}{8}$

Number of half life of A in 16 seconds

$n_A = \frac{16}{4} = 4$

Number of hal life of B in 16 seconds

$n_B = \frac{16}{8} = 2$

Number of nucleus decayed after *n* half life is

$N = N_0\left(1 - \frac{1}{2^n}\right)$

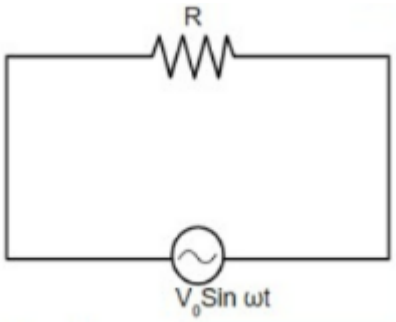
$\frac{NA}{NB} = \frac{NA_0}{NB_0} \frac{\left(1 - \frac{1}{2^{nA}}\right)}{\left(1 - \frac{1}{2^{nB}}\right)}$

$\frac{NA}{NB} = \frac{2}{1} \frac{\left(1 - \frac{1}{2^4}\right)}{\left(1 - \frac{1}{2^2}\right)}$

$$\frac{NA}{NB} = 2\left(\frac{15}{16}\right)\Big/\frac{3}{4}$$

$$\frac{NA}{NB} = \frac{5}{2}$$

18. In a given AC circuit which has maximum voltage Vo and Frequency 50 HZ. Find the time instant where the current in the circuit will be equal to RMS value of circuit



(1) 1.5 ms

(2) 2.5 ms

(3) 4.5 ms

(4) 3.5 ms

Sol: Answer (2)

In the circuit , $i = \frac{V_o \sin \omega t}{R}$ also $i = \frac{I_o}{\sqrt{2}}$

$$\omega = 2\pi f$$

Hence, t = t, $\frac{I_o}{\sqrt{2}} = \frac{V_o \sin \omega t}{R} = 100\pi$

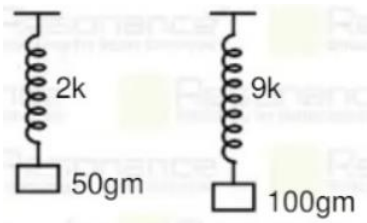
$$\frac{1}{\sqrt{2}} = \text{sinwt}$$

$$\sin\frac{\pi}{4} = \sin \omega \text{t}$$

$$t = \frac{\pi}{4\omega} = \frac{\pi}{4 \times 100\pi} = \frac{1}{400}$$

$$t = 2.5ms$$

19. We have two spring block systems as shown in figure



During oscillation maximum speed of both block in same. Find the ratio of Amplitude of oscillation of Blocks?

(1) $\frac{1}{2}$ (2) $\frac{3}{2}$

(3) $\frac{1}{4}$ (4) $\frac{7}{2}$

Sol. Answer (2)

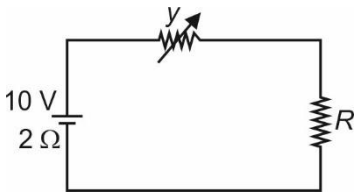
$$V_{man} = \omega_1 A_2 = \omega_2 A_2$$

$$\frac{A_1}{A_2} = \frac{\omega_2}{\omega_1} = \frac{\sqrt{K_2 / m_2}}{\sqrt{K_1 / m_1}}$$

$$= \frac{\sqrt{K_2}}{\sqrt{K_1}} \times \frac{\sqrt{m_2}}{\sqrt{m_1}}$$

$$= \frac{\sqrt{9k}}{\sqrt{2K}} \times \frac{\sqrt{50}}{100} = \frac{3}{2}$$

20. In the figure shown, the power generated in y is maximum if y = 8 Ω. The value of resistance of resistor marked as R is



(1) 6 Ω (2) 8 Ω

(3) 10 Ω (4) 4 Ω

Sol. Answer (1)

Maximum power transfer theorem

$\Rightarrow y = R + 2 \Rightarrow R = 6\ \Omega$

21. If distance between Sun and Earth is R. How years will the early taken to complete one revolution if distance is 3R.

Sol. Answer (5.196)

Given R = Average distance between Sun & Earth

We know that

$$T^2 = kR^3$$

$$\frac{T_1}{T_2} = \left(\frac{R_1}{R_2}\right)^{\frac{3}{2}}$$

$$T_1 = 1\,\text{year}$$

$$R_1 = R$$

$$T_2 = ?$$

$$R_2 = 3R\ (given)$$

$$\frac{1^2}{T_2^2} = \left(\frac{R}{3R}\right)^3 = \left(\frac{1}{3}\right)^3$$

$$T_2 = (3)^{\frac{3}{2}} \times 1 \text{ year}$$

$$T_2 = 3\sqrt{3} \text{ years}$$

$$T_2 = 5.196 \text{ years}$$

22. A projectile fired at an angle 45º with horizontal. After 2 seconds, its velocity is 20 m/s, and the range is 80 m. Find the velocity of projection

Sol. Answer (28.28 m/s)

$$u_x = u\cos 45^o$$

$$u_y = u\sin 45^o$$

$$v_x = u_x = u\cos 45^o$$

$$v_y = u_y - gt$$

$$v_y = u\sin 45^o - 20$$

$$v^2 = v_x^2 + v_y^2$$

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$(20)^2 = (u\cos 45)^2 + (u\sin 45 - 20)^2$$

$$R_{max} = \frac{u^2}{g} = 80 \text{ m}$$

$$u^2 - 40u\sin 45 = 0$$

$$u = 40\sin 45$$

$$u = 20\sqrt{2} \text{ m/s}$$

23. A carnot engine absorbs heat 500 kcal at 727º C and rejects it at 127º C. Find work done (in kcal) by carnot engine.

Sol. Answer (750)

$$Q_2 = 500 \text{ kcal}$$

$$T_1 = 727 + 273 = 1000\ k$$

$$T_2 = 127 + 273 = 400\ k$$

We have, $x = \frac{w}{Q_1} = 1 - \frac{T_2}{T_1}$

But $Q_1 = Q_2 + w$

$$\therefore 1 - \frac{T_2}{T_1} = \frac{w}{Q_2 + w}$$

$$\Rightarrow 1 - \frac{4}{10} = \frac{w}{500 + w}$$

$$\Rightarrow w = 750 \text{ kcal}$$

24. If the energy of capacitor increases by 44% then, find percentage change in charge stored in capacitor

Sol. Answer (20.0)

$$U = \frac{1}{2}\frac{q^2}{C}$$

$$U_i = \frac{q_i^2}{2C} \,\&\, U_f = \frac{q_f^2}{2c}$$

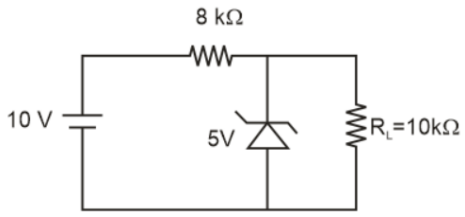
$$\frac{q_f^2}{2c} = 1.44\frac{q_i^2}{2c}$$

$$\Rightarrow q_f = 1.2qi$$

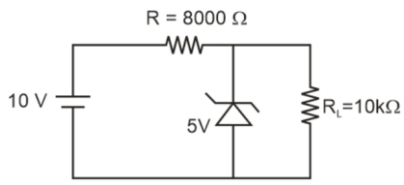
So $\frac{q_f - q_i}{q_i} = 0.2$

So % change in q = 20%

25. In the circuit shown, current through zener diode (in mA) is



Sol. Answer (0.125)



$$i_L = \frac{5}{10000} = 0.5 \text{mA}$$

$$i_R = \frac{5}{8000} = 0.625 \text{mA}$$

$\therefore\ i_z = i_R - i_L = 0.625 - 0.5$ (KCL)

= 0.125 mA

26. Q is the heat supplied to a system containing monoatomic gas. During the process if work done by the gas is $\frac{Q}{4}$ then molar specific heat during the process is *xR*. Value of x is equal to _____ .

Sol. Answer (2)

$$\Delta U = Q - \frac{Q}{4}$$

$$\Rightarrow nC_v\Delta T = \frac{3Q}{4}$$

$$\Rightarrow n \times \left(\frac{3R}{2}\right)\Delta T = \frac{3Q}{4}$$

$$\Rightarrow \frac{Q}{n\Delta T} = \frac{3}{2}R \times \frac{4}{3}$$

$$\therefore C = \frac{Q}{n\Delta T} = 2R$$

$$\therefore \ x = 2$$

27. Wattless current flows through AC circuit, then the circuit is

(1) RLC

(2) R only

(3) L only

(4) RC only

Sol. Answer (3)

A current is said to be wattles if the average power consumed by the circuit is zero

$$< P_{avg} > \ = V_{rms} I_{rms} \cos\phi$$

Wattless component of current

$$I_{rms} \sin\phi = I_{wattless}$$

In the given combination

Only L (inductor) connected across a AC source will have zero average power.