

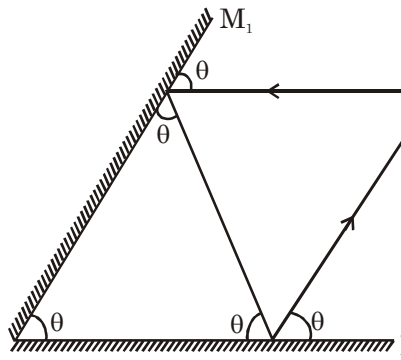
TEST PAPER OF JEE(MAIN) EXAMINATION – 2019

(Held On Wednesday 09th JANUARY, 2019) TIME : 2 : 30 PM To 05 : 30 PM

PHYSICS

1. Two plane mirrors are inclined to each other such that a ray of light incident on the first mirror (M_1) and parallel to the second mirror (M_2) is finally reflected from the second mirror (M_2) parallel to the first mirror (M_1). The angle between the two mirrors will be :
 (1) 90° (2) 45° (3) 75° (4) 60°

Ans. (4)

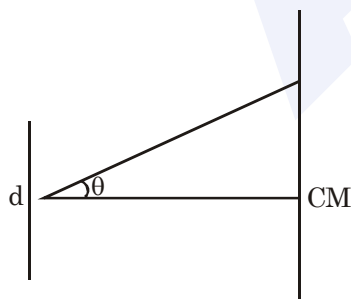


Sol.

Assuming angles between two mirrors be θ as per geometry, sum of angles of Δ
 $3\theta = 180^\circ$
 $\theta = 60^\circ$

2. In a Young's double slit experiment, the slits are placed 0.320 mm apart. Light of wavelength $\lambda = 500$ nm is incident on the slits. The total number of bright fringes that are observed in the angular range $-30^\circ \leq \theta \leq 30^\circ$ is:
 (1) 320 (2) 641 (3) 321 (4) 640

Ans. (2)



Sol.

Path difference
 $d \sin \theta = n\lambda$
 where d = separation of slits
 λ = wave length
 n = no. of maximas
 $0.32 \times 10^{-3} \sin 30 = n \times 500 \times 10^{-9}$
 $n = 320$

Hence total no. of maximas observed in angular range $-30^\circ \leq \theta \leq 30^\circ$ is
 maximas = $320 + 1 + 320 = 641$

3. At a given instant, say $t = 0$, two radioactive substances A and B have equal activities. The ratio $\frac{R_B}{R_A}$ of their activities after time t itself decays with time t as e^{-3t} . [If the half-life of A is $t_{1/2}$, the half-life of B is :
 (1) $\frac{\ln 2}{2}$ (2) $2 \ln 2$ (3) $\frac{\ln 2}{4}$ (4) $4 \ln 2$

Ans. (3)

Sol. Half life of A = $\ln 2$

$$t_{1/2} = \frac{\ln 2}{\lambda}$$

$$\lambda_A = 1$$

$$\text{at } t = 0 \quad R_A = R_B$$

$$N_A e^{-\lambda_A t} = N_B e^{-\lambda_B t}$$

$$N_A = N_B \text{ at } t = 0$$

$$\text{at } t = t \quad \frac{R_B}{R_A} = \frac{N_0 e^{-\lambda_B t}}{N_0 e^{-\lambda_A t}}$$

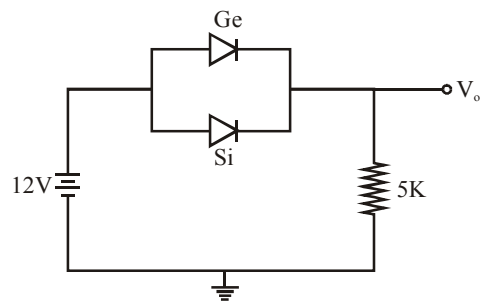
$$e^{-(\lambda_B - \lambda_A)t} = e^{-t}$$

$$\lambda_B - \lambda_A = 3$$

$$\lambda_B = 3 + \lambda_A = 4$$

$$t_{1/2} = \frac{\ln 2}{\lambda_B} = \frac{\ln 2}{4}$$

4. Ge and Si diodes start conducting at 0.3 V and 0.7 V respectively. In the following figure if Ge diode connection are reversed, the value of V_o changes by : (assume that the Ge diode has large breakdown voltage)



- (1) 0.6 V (2) 0.8 V (3) 0.4 V (4) 0.2 V

Ans. (3)

Sol. Initially Ge & Si are both forward biased so current will effectively pass through Ge diode with a drop of 0.3 V

if "Ge" is reversed then current will flow through "Si" diode hence an effective drop of $(0.7 - 0.3) = 0.4$ V is observed.

5. A rod of mass 'M' and length '2L' is suspended at its middle by a wire. It exhibits torsional oscillations; If two masses each of 'm' are attached at distance 'L/2' from its centre on both sides, it reduces the oscillation frequency by 20%. The value of ratio m/M is close to :
(1) 0.17 (2) 0.37 (3) 0.57 (4) 0.77

Ans. (2)

Sol. Frequency of torsional oscillations is given by

$$f = \frac{k}{\sqrt{I}}$$

$$f_1 = \frac{k}{\sqrt{\frac{M(2L)^2}{12}}}$$

$$f_2 = \frac{k}{\sqrt{\frac{M(2L)^2}{12} + 2m\left(\frac{L}{2}\right)^2}}$$

$$f_2 = 0.8 f_1$$

$$\frac{m}{M} = 0.375$$

6. A 15 g mass of nitrogen gas is enclosed in a vessel at a temperature 27°C. Amount of heat transferred to the gas, so that rms velocity of molecules is doubled, is about :

[Take R = 8.3 J/ K mole]

- (1) 10 kJ (2) 0.9 kJ (3) 6 kJ (4) 14 kJ

Ans. (1)

Sol. $Q = nC_v\Delta T$ as gas in closed vessel

$$Q = \frac{15}{28} \times \frac{5 \times R}{2} \times (4T - T)$$

$$Q = 10000 \text{ J} = 10 \text{ kJ}$$

7. A particle is executing simple harmonic motion (SHM) of amplitude A, along the x-axis, about $x = 0$. When its potential Energy (PE) equals kinetic energy (KE), the position of the particle will be :

- (1) $\frac{A}{2}$ (2) $\frac{A}{2\sqrt{2}}$ (3) $\frac{A}{\sqrt{2}}$ (4) A

Ans. (3)

Sol. Potential energy (U) = $\frac{1}{2}kx^2$

$$\text{Kinetic energy (K)} = \frac{1}{2}kA^2 - \frac{1}{2}kx^2$$

According to the question, $U = K$

$$\therefore \frac{1}{2}kx^2 = \frac{1}{2}kA^2 - \frac{1}{2}kx^2$$

$$x = \pm \frac{A}{\sqrt{2}}$$

\therefore Correct answer is (3)

8. A musician using an open flute of length 50 cm produces second harmonic sound waves. A person runs towards the musician from another end of a hall at a speed of 10 km/h. If the wave speed is 330 m/s, the frequency heard by the running person shall be close to :

- (1) 753 Hz (2) 500 Hz
(3) 333 Hz (4) 666 Hz

Ans. (4)

Sol. Frequency of the sound produced by flute,

$$f = 2\left(\frac{v}{2\ell}\right) = \frac{2 \times 330}{2 \times 0.5} = 660 \text{ Hz}$$

$$\text{Velocity of observer, } v_0 = 10 \times \frac{5}{18} = \frac{25}{9} \text{ m/s}$$

\therefore frequency detected by observer, $f' =$

$$\left[\frac{v + v_0}{v}\right] f$$

$$\therefore f' = \left[\frac{\frac{25}{9} + 330}{330}\right] 660$$

$$= 335.56 \times 2 = 671.12$$

\therefore closest answer is (4)

9. In a communication system operating at wavelength 800 nm, only one percent of source frequency is available as signal bandwidth. The number of channels accommodated for transmitting TV signals of band width 6 MHz are (Take velocity of light $c = 3 \times 10^8$ m/s, $h = 6.6 \times 10^{-34}$ J-s)

- (1) 3.75×10^6 (2) 4.87×10^5
(3) 3.86×10^6 (4) 6.25×10^5

Ans. (4)

Sol. $f = \frac{3 \times 10^8}{8 \times 10^{-7}} = \frac{30}{8} \times 10^{14} \text{ Hz}$
 $= 3.75 \times 10^{14} \text{ Hz}$
 1% of $f = 0.0375 \times 10^{14} \text{ Hz}$
 $= 3.75 \times 10^{12} \text{ Hz} = 3.75 \times 10^6 \text{ MHz}$

number of channels = $\frac{3.75 \times 10^6}{6} = 6.25 \times 10^5$

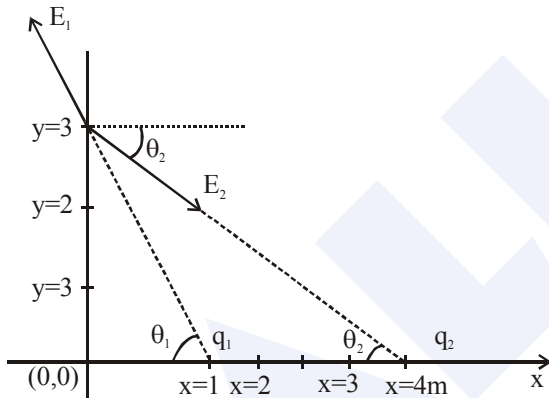
∴ correct answer is (4)

- 10.** Two point charges $q_1(\sqrt{10} \mu\text{C})$ and $q_2(-25 \mu\text{C})$ are placed on the x-axis at $x = 1 \text{ m}$ and $x = 4 \text{ m}$ respectively. The electric field (in V/m) at a point $y = 3 \text{ m}$ on y-axis is,

$\left[\text{take } \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2} \right]$

- (1) $(-63\hat{i} + 27\hat{j}) \times 10^2$ (2) $(81\hat{i} - 81\hat{j}) \times 10^2$
 (3) $(63\hat{i} - 27\hat{j}) \times 10^2$ (4) $(-81\hat{i} + 81\hat{j}) \times 10^2$

Ans. (3)



Sol.

Let \vec{E}_1 & \vec{E}_2 are the values of electric field due to q_1 & q_2 respectively magnitude of

$E_2 = \frac{1}{4\pi\epsilon_0} \frac{q_2}{r^2}$

$E_2 = \frac{9 \times 10^9 \times (25) \times 10^{-6}}{(4^2 + 3^2)} \text{ V/m}$

$E_2 = 9 \times 10^3 \text{ V/m}$

$\therefore \vec{E}_2 = 9 \times 10^3 (\cos\theta_2 \hat{i} - \sin\theta_2 \hat{j})$
 $\therefore \tan\theta_2 = \frac{3}{4}$

$\therefore \vec{E}_2 = 9 \times 10^3 \left(\frac{4}{5} \hat{i} - \frac{3}{5} \hat{j} \right) = (72\hat{i} - 54\hat{j}) \times 10^2$

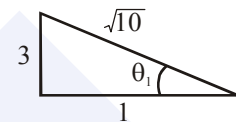
Magnitude of $E_1 = \frac{1}{4\pi\epsilon_0} \frac{\sqrt{10} \times 10^{-6}}{(1^2 + 3^2)}$

$= (9 \times 10^9) \times \sqrt{10} \times 10^{-7}$

$= 9\sqrt{10} \times 10^2$

$\therefore \vec{E}_1 = 9\sqrt{10} \times 10^2 [\cos\theta_1 (-\hat{i}) + \sin\theta_1 \hat{j}]$

$\therefore \tan\theta_1 = 3$



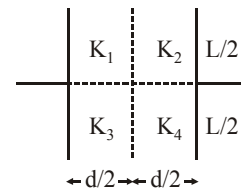
$E_1 = 9 \times \sqrt{10} \times 10^2 \left[\frac{1}{\sqrt{10}} (-\hat{i}) + \frac{3}{\sqrt{10}} \hat{j} \right]$

$E_1 = 9 \times 10^2 [-\hat{i} + 3\hat{j}] = [-9\hat{i} + 27\hat{j}] 10^2$

$\therefore \vec{E} = \vec{E}_1 + \vec{E}_2 = (63\hat{i} - 27\hat{j}) \times 10^2 \text{ V/m}$

∴ correct answer is (3)

- 11.** A parallel plate capacitor with square plates is filled with four dielectrics of dielectric constants K_1, K_2, K_3, K_4 arranged as shown in the figure. The effective dielectric constant K will be :



(1) $K = \frac{(K_1 + K_2)(K_3 + K_4)}{2(K_1 + K_2 + K_3 + K_4)}$

(2) $K = \frac{(K_1 + K_2)(K_3 + K_4)}{(K_1 + K_2 + K_3 + K_4)}$

(3) $K = \frac{(K_1 + K_4)(K_2 + K_3)}{2(K_1 + K_2 + K_3 + K_4)}$

(4) $K = \frac{(K_1 + K_3)(K_2 + K_4)}{K_1 + K_2 + K_3 + K_4}$

Ans. (Bonus)

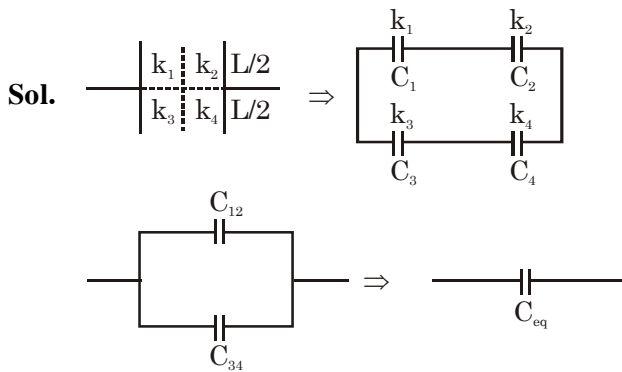
MAJOR COMPUTER BASED TEST (CBT) SERIES

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$$C_{12} = \frac{C_1 C_2}{C_1 + C_2} = \frac{k_1 \epsilon_0 \frac{L}{2} \times L \cdot k_2 \left[\epsilon_0 \frac{L}{2} \times L \right]}{d/2 \cdot \frac{d/2}{(k_1 + k_2) \left[\frac{\epsilon_0 \cdot \frac{L}{2} \times L}{d/2} \right]}}$$

$$C_{12} = \frac{k_1 k_2 \epsilon_0 L^2}{k_1 + k_2 d}$$

in the same way we get, $C_{34} = \frac{k_3 k_4 \epsilon_0 L^2}{k_3 + k_4 d}$

$$\therefore C_{eq} = C_{12} + C_{34} = \left[\frac{k_1 k_2}{k_1 + k_2} + \frac{k_3 k_4}{k_3 + k_4} \right] \frac{\epsilon_0 L^2}{d} \dots(i)$$

Now if $k_{eq} = k$, $C_{eq} = \frac{k \epsilon_0 L^2}{d} \dots(ii)$

on comparing equation (i) to equation (ii), we get

$$k_{eq} = \frac{k_1 k_2 (k_3 + k_4) + k_3 k_4 (k_1 + k_2)}{(k_1 + k_2)(k_3 + k_4)}$$

This does not match with any of the options so probably they have assumed the wrong combination

$$C_{13} = \frac{k_1 \epsilon_0 L \frac{L}{2}}{d/2} + k_3 \epsilon_0 \frac{L \cdot \frac{L}{2}}{d/2}$$

$$= (k_1 + k_3) \frac{\epsilon_0 L^2}{d}$$

$$C_{24} = (k_2 + k_4) \frac{\epsilon_0 L^2}{d}$$

$$C_{eq} = \frac{C_{13} C_{24}}{C_{13} + C_{24}} = \frac{(k_1 + k_3)(k_2 + k_4) \epsilon_0 L^2}{(k_1 + k_2 + k_3 + k_4) d}$$

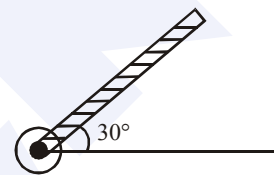
$$= \frac{k \epsilon_0 L^2}{d}$$

$$k = \frac{(k_1 + k_3)(k_2 + k_4)}{(k_1 + k_2 + k_3 + k_4)}$$

However this is one of the four options.

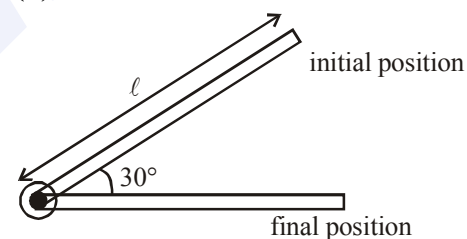
It must be a "Bonus" logically but of the given options probably they might go with (4)

12. A rod of length 50cm is pivoted at one end. It is raised such that it makes an angle of 30° from the horizontal as shown and released from rest. Its angular speed when it passes through the horizontal (in rad s^{-1}) will be ($g = 10\text{ms}^{-2}$)



- (1) $\sqrt{30}$ (2) $\sqrt{\frac{30}{2}}$ (3) $\frac{\sqrt{30}}{2}$ (4) $\frac{\sqrt{20}}{3}$

Ans. (2)



Sol.

Work done by gravity from initial to final position is,

$$W = mg \frac{l}{2} \sin 30^\circ$$

$$= \frac{mg l}{4}$$

According to work energy theorem

$$W = \frac{1}{2} I \omega^2$$

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$$\Rightarrow \frac{1}{2} \frac{m\ell^2}{3} \omega^2 = \frac{mg\ell}{4}$$

$$\omega = \sqrt{\frac{3g}{2\ell}} = \sqrt{\frac{3 \times 10}{2 \times 0.5}}$$

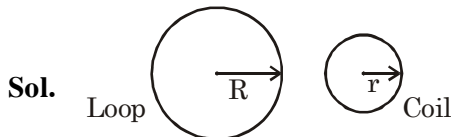
$$\omega = \sqrt{30} \text{ rad/sec}$$

∴ correct answer is (1)

- 13.** One of the two identical conducting wires of length L is bent in the form of a circular loop and the other one into a circular coil of N identical turns. If the same current is passed in both, the ratio of the magnetic field at the central of the loop (B_L) to that at the centre of the coil (B_C), i.e. $R \frac{B_L}{B_C}$ will be :

- (1) $\frac{1}{N}$ (2) N^2 (3) $\frac{1}{N^2}$ (4) N

Ans. (3)



$$L = 2\pi R \quad L = N \times 2\pi r$$

$$R = Nr$$

$$B_L = \frac{\mu_0 I}{2R} \quad B_C = \frac{\mu_0 Ni}{2r}$$

$$B_C = \frac{\mu_0 N^2 i}{2R}$$

$$\frac{B_L}{B_C} = \frac{1}{N^2}$$

- 14.** The energy required to take a satellite to a height 'h' above Earth surface (radius of Earth = 6.4×10^3 km) is E_1 and kinetic energy required for the satellite to be in a circular orbit at this height is E_2 . The value of h for which E_1 and E_2 are equal, is:
- (1) 1.28×10^4 km (2) 6.4×10^3 km
(3) 3.2×10^3 km (4) 1.6×10^3 km

Ans. (3)

Sol. $U_{\text{surface}} + E_1 = U_h$
KE of satellite is zero at earth surface & at height h

$$-\frac{GM_e m}{R_e} + E_1 = -\frac{GM_e m}{(R_e + h)}$$

$$E_1 = GM_e m \left(\frac{1}{R_e} - \frac{1}{R_e + h} \right)$$

$$E_1 = \frac{GM_e m}{(R_e + h)} \times \frac{h}{R_e}$$

$$\text{Gravitational attraction } F_G = ma_C = \frac{mv^2}{(R_e + h)}$$

$$E_2 \Rightarrow \frac{mv^2}{(R_e + h)} = \frac{GM_e m}{(R_e + h)^2}$$

$$mv^2 = \frac{GM_e m}{(R_e + h)}$$

$$E_2 = \frac{mv^2}{2} = \frac{GM_e m}{2(R_e + h)}$$

$$E_1 = E_2$$

$$\frac{h}{R_e} = \frac{1}{2} \Rightarrow h = \frac{R_e}{2} = 3200 \text{ km}$$

- 15.** The energy associated with electric field is (U_E) and with magnetic field is (U_B) for an electromagnetic wave in free space. Then :

- (1) $U_E = \frac{U_B}{2}$ (2) $U_E < U_B$
(3) $U_E = U_B$ (4) $U_E > U_B$

Ans. (3)

Sol. Average energy density of magnetic field,

$$u_B = \frac{B_0^2}{2\mu_0}, \quad B_0 \text{ is maximum value of magnetic field.}$$

Average energy density of electric field,

$$u_E = \frac{\epsilon_0 E_0^2}{2}$$

$$\text{now, } \epsilon_0 = CB_0, \quad C^2 = \frac{1}{\mu_0 \epsilon_0}$$

$$u_E = \frac{\epsilon_0}{2} \times C^2 B_0^2$$

$$= \frac{\epsilon_0}{2} \times \frac{1}{\mu_0 \epsilon_0} \times B_0^2 = \frac{B_0^2}{2\mu_0} = u_B$$

$u_E = u_B$
since energy density of electric & magnetic field is same, energy associated with equal volume will be equal.

$$u_E = u_B$$

- 16.** A series AC circuit containing an inductor (20 mH), a capacitor (120 μ F) and a resistor (60 Ω) is driven by an AC source of 24 V/50 Hz. The energy dissipated in the circuit in 60 s is :

- (1) 2.26×10^3 J (2) 3.39×10^3 J
(3) 5.65×10^2 J (4) 5.17×10^2 J

Ans. (4)

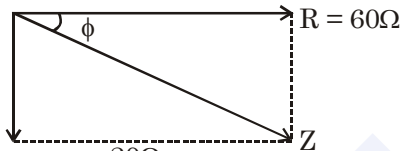
Sol. $R = 60\Omega$ $f = 50\text{Hz}$, $\omega = 2\pi f = 100 \pi$

$$x_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 120 \times 10^{-6}}$$

$$x_C = 26.52 \Omega$$

$$x_L = \omega L = 100\pi \times 20 \times 10^{-3} = 2\pi\Omega$$

$$x_C - x_L = 20.24 \approx 20$$



$$x_C - x_L = 20\Omega$$

$$Z = \sqrt{R^2 + (x_C - x_L)^2}$$

$$Z = 20\sqrt{10}\Omega$$

$$\cos\phi = \frac{R}{Z} = \frac{3}{\sqrt{10}}$$

$$P_{\text{avg}} = VI \cos \phi, I = \frac{V}{Z}$$

$$= \frac{V^2}{Z} \cos \phi$$

$$= 8.64 \text{ watt}$$

$$Q = P.t = 8.64 \times 60 = 5.18 \times 10^2$$

- 17.** Expression for time in terms of G (universal gravitational constant), h (Planck constant) and c (speed of light) is proportional to :

(1) $\sqrt{\frac{Gh}{c^3}}$ (2) $\sqrt{\frac{hc^5}{G}}$

(3) $\sqrt{\frac{c^3}{Gh}}$ (4) $\sqrt{\frac{Gh}{c^5}}$

Ans. (4)

Sol. $F = \frac{GM^2}{R^2} \Rightarrow G = [M^{-1}L^3T^{-2}]$

$$E = hv \Rightarrow h = [ML^2T^{-1}]$$

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

$$t \propto G^x h^y C^z$$

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

$$[M^0L^0T^1] = [M^{-x+y}L^{3x+2y+z}T^{-2x-y-z}]$$

on comparing the powers of M, L, T

$$-x + y = 0 \Rightarrow x = y$$

$$3x + 2y + z = 0 \Rightarrow 5x + z = 0 \quad \dots(i)$$

$$-2x - y - z = 1 \Rightarrow 3x + z = -1 \quad \dots(ii)$$

on solving (i) & (ii) $x = y = \frac{1}{2}$, $z = -\frac{5}{2}$

$$t \propto \sqrt{\frac{Gh}{C^5}}$$

- 18.** The magnetic field associated with a light wave is given, at the origin, by

$B = B_0 [\sin(3.14 \times 10^7)ct + \sin(6.28 \times 10^7)ct]$. If this light falls on a silver plate having a work function of 4.7 eV, what will be the maximum kinetic energy of the photo electrons ?

$$(c = 3 \times 10^8 \text{ms}^{-1}, h = 6.6 \times 10^{-34} \text{J-s})$$

- (1) 7.72 eV (2) 8.52 eV
(3) 12.5 eV (4) 6.82 eV

Ans. (1)

Sol. $B = B_0 \sin(\pi \times 10^7 C)t + B_0 \sin(2\pi \times 10^7 C)t$
since there are two EM waves with different frequency, to get maximum kinetic energy we take the photon with higher frequency

$$B_1 = B_0 \sin(\pi \times 10^7 C)t \quad v_1 = \frac{10^7}{2} \times C$$

$$B_2 = B_0 \sin(2\pi \times 10^7 C)t \quad v_2 = 10^7 C$$

where C is speed of light $C = 3 \times 10^8$ m/s

$$v_2 > v_1$$

so KE of photoelectron will be maximum for photon of higher energy.

$$v_2 = 10^7 C \text{ Hz}$$

$$hv = \phi + KE_{\text{max}}$$

energy of photon

$$E_{\text{ph}} = hv = 6.6 \times 10^{-34} \times 10^7 \times 3 \times 10^8$$

$$E_{\text{ph}} = 6.6 \times 3 \times 10^{-19} \text{J}$$

$$= \frac{6.6 \times 3 \times 10^{-19}}{1.6 \times 10^{-19}} \text{eV} = 12.375 \text{eV}$$

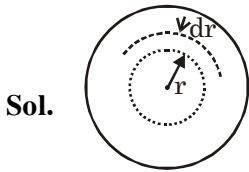
$$KE_{\text{max}} = E_{\text{ph}} - \phi$$

$$= 12.375 - 4.7 = 7.675 \text{ eV} \approx 7.7 \text{ eV}$$

19. Charge is distributed within a sphere of radius R with a volume charge density $\rho(r) = \frac{A}{r^2} e^{-2r/a}$, where A and a are constants. If Q is the total charge of this charge distribution, the radius R is :

- (1) $\frac{a}{2} \log\left(1 - \frac{Q}{2\pi a A}\right)$ (2) $a \log\left(1 - \frac{Q}{2\pi a A}\right)$
 (3) $a \log\left(\frac{1}{1 - \frac{Q}{2\pi a A}}\right)$ (4) $\frac{a}{2} \log\left(\frac{1}{1 - \frac{Q}{2\pi a A}}\right)$

Ans. (4)



$$Q = \int \rho dv$$

$$= \int_0^R \frac{A}{r^2} e^{-2r/a} (4\pi r^2 dr)$$

$$= \int_0^R \frac{A}{r^2} e^{-2r/a} (4\pi r^2 dr)$$

$$= 4\pi A \int_0^R e^{-2r/a} dr$$

$$= 4\pi A \left[\frac{e^{-2r/a}}{-\frac{2}{a}} \right]_0^R$$

$$= 4\pi A \left(-\frac{a}{2} \right) (e^{-2R/a} - 1)$$

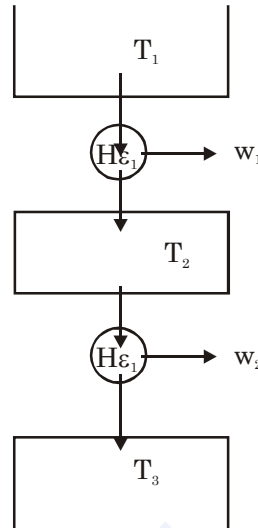
$$Q = 2\pi a A (1 - e^{-2R/a})$$

$$R = \frac{a}{2} \log\left(\frac{1}{1 - \frac{Q}{2\pi a A}}\right)$$

20. Two Carnot engines A and B are operated in series. The first one, A, receives heat at $T_1 (= 600 \text{ K})$ and rejects to a reservoir at temperature T_2 . The second engine B receives heat rejected by the first engine and, in turn, rejects to a heat reservoir at $T_3 (= 400 \text{ K})$. Calculate the temperature T_2 if the work outputs of the two engines are equal :

- (1) 400 K (2) 600 K (3) 500 K (4) 300 K

Ans. (3)



Sol.

$$w_1 = w_2$$

$$\Delta u_1 = \Delta u_2$$

$$T_3 - T_2 = T_2 - T_1$$

$$2T_2 = T_1 + T_3$$

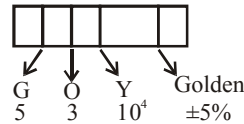
$$T_2 = 500 \text{ K}$$

21. A carbon resistance has a following colour code. What is the value of the resistance ?



- (1) 1.64 MΩ ± 5% (2) 530 kΩ ± 5%
 (3) 64 kΩ ± 10% (4) 5.3 MΩ ± 5%

Ans. (2)



Sol.

$$R = 53 \times 10^4 \pm 5\% = 530 \text{ k}\Omega \pm 5\%$$

22. A force acts on a 2 kg object so that its position is given as a function of time as $x = 3t^2 + 5$. What is the work done by this force in first 5 seconds ?

- (1) 850 J (2) 900 J
 (3) 950 J (4) 875 J

Ans. (2)

Sol. $x = 3t^2 + 5$

$$v = \frac{dx}{dt}$$

$$v = 6t + 0$$

$$\text{at } t = 0 \quad v = 0$$

$$t = 5 \text{ sec} \quad v = 30 \text{ m/s}$$

$$\text{W.D.} = \Delta \text{KE}$$

$$\text{W.D.} = \frac{1}{2}mv^2 - 0 = \frac{1}{2}(2)(30)^2 = 900 \text{ J}$$

23. The position co-ordinates of a particle moving in a 3-D coordinate system is given by

$$x = a \cos \omega t$$

$$y = a \sin \omega t$$

$$\text{and } z = a \omega t$$

The speed of the particle is :

- (1) $a\omega$ (2) $\sqrt{3} a\omega$
(3) $\sqrt{2} a\omega$ (4) $2a\omega$

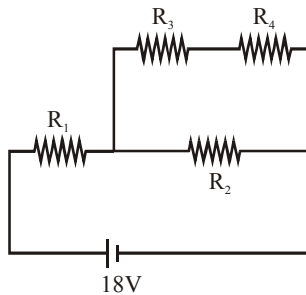
Ans. (3)

Sol. $v_x = -a\omega \sin \omega t \Rightarrow v_y = a\omega \cos \omega t$

$$v_z = a\omega \Rightarrow v = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

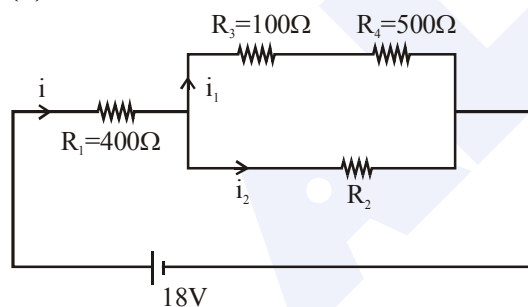
$$v = \sqrt{2} a\omega$$

24. In the given circuit the internal resistance of the 18 V cell is negligible. If $R_1 = 400 \Omega$, $R_3 = 100 \Omega$ and $R_4 = 500 \Omega$ and the reading of an ideal voltmeter across R_4 is 5V, then the value R_2 will be :



- (1) 300Ω (2) 230Ω
(3) 450Ω (4) 550Ω

Ans. (1)



Sol.

$$V_4 = 5V$$

$$i_1 = \frac{V_4}{R_4} = 0.01 A$$

$$V_3 = i_1 R_3 = 1V$$

$$V_3 + V_4 = 6V = V_2$$

$$V_1 + V_3 + V_4 = 18V$$

$$V_1 = 12V$$

$$i = \frac{V_1}{R_1} = 0.03 \text{ Amp.}$$

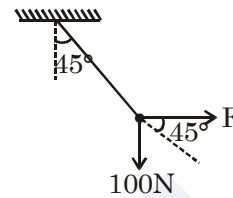
$$i_2 = 0.02 \text{ Amp} \quad V_2 = 6V$$

$$R_2 = \frac{V_2}{i_2} = \frac{6}{0.02} = 300 \Omega$$

25. A mass of 10 kg is suspended vertically by a rope from the roof. When a horizontal force is applied on the rope at some point, the rope deviated at an angle of 45° at the roof point. If the suspended mass is at equilibrium, the magnitude of the force applied is ($g = 10 \text{ ms}^{-2}$)

- (1) 200 N (2) 100 N (3) 140 N (4) 70 N

Ans. (2)



Sol.

at equation

$$\tan 45^\circ = \frac{100}{F}$$

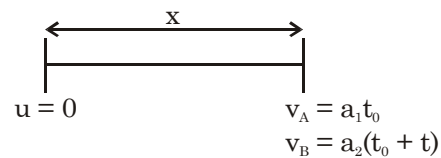
$$F = 100 \text{ N}$$

26. In a car race on straight road, car A takes a time t less than car B at the finish and passes finishing point with a speed ' v ' more than that of car B. Both the cars start from rest and travel with constant acceleration a_1 and a_2 respectively. Then ' v ' is equal to

- (1) $\frac{a_1 + a_2}{2} t$ (2) $\sqrt{2a_1 a_2} t$
(3) $\frac{2a_1 a_2}{a_1 + a_2} t$ (4) $\sqrt{a_1 a_2} t$

Ans. (4)

Sol. For A & B let time taken by A is t_0



from ques.

$$v_A - v_B = v = (a_1 - a_2)t_0 - a_2 t \quad \dots(i)$$

$$x_B = x_A = \frac{1}{2} a_1 t_0^2 = \frac{1}{2} a_2 (t_0 + t)^2$$

$$\Rightarrow \sqrt{a_1} t_0 = \sqrt{a_2} (t_0 + t)$$

$$\Rightarrow (\sqrt{a_2} - \sqrt{a_1}) t_0 = \sqrt{a_2} t \quad \dots(ii)$$

putting t_0 in equation

$$v = (a_1 - a_2) \frac{\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}} - a_2t$$

$$= (\sqrt{a_1} + \sqrt{a_2})\sqrt{a_2}t - a_2t \Rightarrow v = \sqrt{a_1 a_2}t$$

$$\Rightarrow \sqrt{a_1 a_2}t + a_2t - a_2t$$

27. A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. The output power is delivered at 230 V by the transformer. If the current in the primary of the transformer is 5A and its efficiency is 90%, the output current would be :

- (1) 25 A (2) 50 A
(3) 35 A (4) 45 A

Ans. (4)

Sol. $\eta = \frac{P_{out}}{P_{in}} = \frac{V_s I_s}{V_p I_p}$

$$\Rightarrow 0.9 = \frac{23 \times I_s}{230 \times 5}$$

$$\Rightarrow I_s = 45A$$

28. The top of a water tank is open to air and its water level is maintained. It is giving out 0.74 m³ water per minute through a circular opening of 2 cm radius in its wall. The depth of the centre of the opening from the level of water in the tank is close to :

- (1) 9.6 m (2) 4.8 m (3) 2.9 m (4) 6.0 m

Ans. (2)

Sol. In flow volume = outflow volume

$$\Rightarrow \frac{0.74}{60} = (\pi \times 4 \times 10^{-4}) \times \sqrt{2gh}$$

$$\Rightarrow \sqrt{2gh} = \frac{74 \times 100}{240\pi}$$

$$\Rightarrow \sqrt{2gh} = \frac{740}{24\pi}$$

$$\Rightarrow 2gh = \frac{740 \times 740}{24 \times 24 \times 10} (\pi^2 = 10)$$

$$\Rightarrow h = \frac{74 \times 74}{2 \times 24 \times 24}$$

$$\Rightarrow h \approx 4.8m$$

29. The pitch and the number of divisions, on the circular scale, for a given screw gauge are 0.5 mm and 100 respectively. When the screw gauge is fully tightened without any object, the zero of its circular scale lies 3 divisions below the mean line.

The readings of the main scale and the circular scale, for a thin sheet, are 5.5 mm and 48 respectively, the thickness of this sheet is :

- (1) 5.755 m (2) 5.725 mm
(3) 5.740 m (4) 5.950 mm

Ans. (2)

Sol. $LC = \frac{\text{Pitch}}{\text{No. of division}}$

$$LC = 0.5 \times 10^{-2} \text{ mm}$$

$$+ve \text{ error} = 3 \times 0.5 \times 10^{-2} \text{ mm}$$

$$= 1.5 \times 10^{-2} \text{ mm} = 0.015 \text{ mm}$$

$$\text{Reading} = \text{MSR} + \text{CSR} - (+ve \text{ error})$$

$$= 5.5 \text{ mm} + (48 \times 0.5 \times 10^{-2}) - 0.015$$

$$= 5.5 + 0.24 - 0.015 = 5.725 \text{ mm}$$

30. A particle having the same charge as of electron moves in a circular path of radius 0.5 cm under the influence of a magnetic field of 0.5 T. If an electric field of 100 V/m makes it to move in a straight path, then the mass of the particle is (Given charge of electron = $1.6 \times 10^{-19}C$)

- (1) $2.0 \times 10^{-24} \text{ kg}$
(2) $1.6 \times 10^{-19} \text{ kg}$
(3) $1.6 \times 10^{-27} \text{ kg}$
(4) $9.1 \times 10^{-31} \text{ kg}$

Ans. (1)

Sol. $\frac{mv^2}{R} = qvB$

$$mv = qBR \dots(i)$$

Path is straight line
it $qE = qvB$
 $E = vB \dots(ii)$
From equation (i) & (ii)

$$m = \frac{qB^2R}{E}$$

$$m = 2.0 \times 10^{-24} \text{ kg}$$