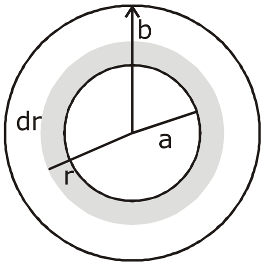
PHYSICS
JEE-MAIN (April-Attempt) 10 April (Shift-2) Paper

SECTION - A

1. Space between two concentric conducting spheres fo radii a and b (b > a) is filled with a medium of ressitivity ρ. The resistance between the two spheres will be:

(1) $\frac{\rho}{4\pi}\left(\frac{1}{a}+\frac{1}{b}\right)$ (2) $\frac{\rho}{4\pi}\left(\frac{1}{a}-\frac{1}{b}\right)$ (3) $\frac{\rho}{2\pi}\left(\frac{1}{a}-\frac{1}{b}\right)$ (4) $\frac{\rho}{2\pi}\left(\frac{1}{a}+\frac{1}{b}\right)$

Sol. **2**



$$dR = s\,\frac{dr}{4\pi r^2}$$

$$\int dR = \frac{1}{4\pi}\int_a^b r^{-2}\,dr$$

$$R = \frac{I}{4\pi}\left[\frac{1}{a}-\frac{1}{b}\right]$$

2. A solid spheer of mass M and radius R is divided into two unequal parts. The first part has a mass of $\frac{7M}{8}$ and is converted into a uniform disc of radius 2R. The second part is converted into a uniform solid sphere. Let I_1 be the moment of inertia of the disc about its axis and I_2 be the moment of inertia of the new sphere about its axis. The ratio I_1/I_2 is given by :

(1) 185 (2) 65 (3) 140 (4) 285

Sol. **3**

$$I_1 = \frac{I}{4\pi}\,\frac{\frac{7M}{8}4R^2}{2} = \frac{7MR^2\times 4}{16}$$

$$I_1 = \frac{7}{4}MR^2$$

$$I_2 = \frac{2}{5}\,\frac{M}{8}\,R_1{}^2 = \frac{MR_1^2}{20}$$

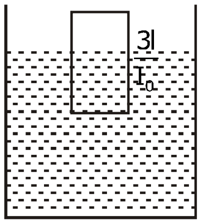
$$\frac{I_1}{I_2} = \frac{7}{4}MR^2\times$$

= 140

3. A cubical block of side 0.5 m floats on water with 30% of its volume under water. What is the maximum weight that can be put on the block without fully submerging it under water ?
[Take, density of water = 10^3 kg/m^3)

(1) 87.5 kg (2) 30.1 kg (3) 65.4 kg (4) 46.3 kg

Sol. **1**



$mg = \delta(A)\frac{3l}{l_0}$

$(M + m)g = \rho A l g$

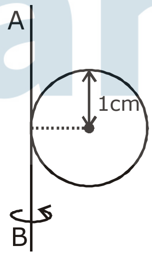
$(M + m) = \rho A l$

$m = \rho A l - \frac{3}{10}\rho A l = \frac{7}{10}\rho A l$

$m = \frac{7 \times 10^3 \times 0.5 \times 0.5 \times 0.5}{10 \times 1000}$

$m = 87.5$ kg

4. A metal coin of mass 5 g and radius 1 cm is fixed to a thin stick AB of negligible mass as shown in the figure. The system is initially at rest. The constant torque, that will make the system rotate about AB at 25 rotations per second in 5s, is close to -



(1) 1.6×10^{-5} Nm (2) 4.0×10^{-6} Nm (3) 2.0×10^{-5} Nm (4) 7.9×10^{-6} Nm

Sol. **3**

$\propto = \frac{2\pi \times 25}{5} = 10\pi$

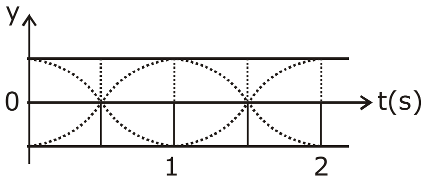
$z = I\propto = \frac{5}{4}MR^2 \times 10\pi$

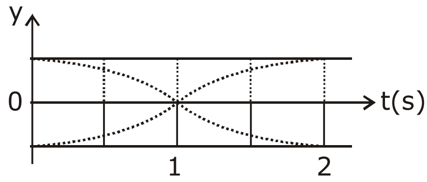
$z = \frac{5}{4} \times 5 \times 10^{-3} \times 1\ 10^{-4} \times 10 \times 3.14$

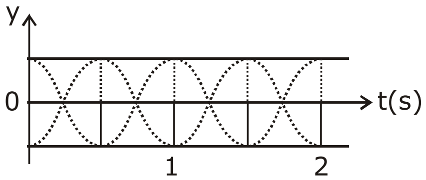
$z = \frac{25 \times 3.14}{4} \times 10^{-6}$ Nm

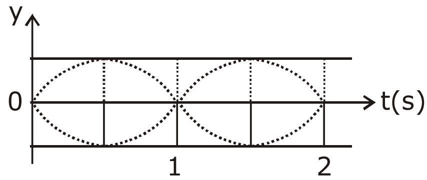
$z = 19.6 \times 10^{-6} \approx 2 \times 10^{-5}$ Nm

5. The correct figure that shows, schematically, the wave pattern produced by superposition of two waves of frequencies 9 Hz and 11 Hz, is -

(1) 

(2) 

(3) 

(4) 

Sol. **3**

y = A sin 18 πt

y = A sin 11 πt

$\overline{y} = \overline{y}_1 + \overline{y}_2$

y = A sin (18 πt) + A sin (11 πt)

t = 0,1,2 y = 0

6. A coil of self inductance 10 mH and resistance 0.1 Ω is connected through a switch to a battery of internal resistance 0.9Ω. After the switch is closed, the time taken for the current to attain 80% of the saturation value is - [Take ln 5 = 1.6]

(1) 0.016 s (2) 0.002 s (3) 0.103 s (4) 0.324 s

Sol. **1**

$$i = i_0\left(1 - e^{-\frac{R}{L}t}\right)$$

$$\frac{8}{10}\, i_0 = i_0\left(1 - e^{-\frac{R}{L}t}\right)$$

$$\frac{1}{5} = e^{-\frac{R}{L}t}$$

$$Ln\,(5) = \frac{R}{L}\,t$$

$$t = \frac{[X]}{[Z^2]}\ln(5)$$

$$t = \frac{10 \times 10^{-3}}{I}\ln(5)$$

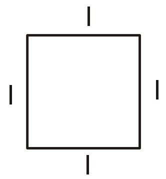
$t = 10^{-2} \times 1.6$

t = 0.016 sec

7. A square loop is carrying a steady curent I and the magnitude of its magnetic dipole moment is m. If this square loop is changed to a circular loop and it carries the same current, the magnitude of the magnetic dipole moment of circular loop will be -

(1) $\frac{4m}{\pi}$ (2) $\frac{3m}{\pi}$ (3) $\frac{m}{\pi}$ (4) $\frac{2m}{\pi}$

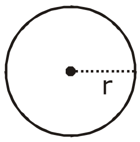
Sol. **1**



$m = Ni\ l^2$

$N = 1$

$m = il^2$



$2\pi r = 4l$

$r = \frac{4l}{2\pi} = \frac{2l}{\pi}$

$M = i\pi r^2$

$M = i\ \pi\ \frac{4l^2}{\pi^2} = \frac{4m}{\pi}$

8. In the formula $X = 5YZ^2$, X and Z have dimensions of capacitance and magnetic field, respectively. What are the dimensions of Y in SI units ?

(1) $[M^{-2}\ L^{-2}\ T^6\ A^3]$ (2) $[M^{-1}\ L^{-2}\ T^4\ A^2]$ (3) $[M^{-2}\ L^0\ T^{-4}\ A^{-2}]$ (4) $[M^{-3}\ L^{-2}\ T^8\ A^4]$

Sol. **4**

$B = MT^{-2}\ A^{-1}$

$F = BIL$

$C = M^{-1}\ L^{-2}\ A^{-2}\ T^4 \quad C = \frac{q^2}{2E}$

$[y] = \frac{[x]}{[z^2]} = M^{-3}\ L^{-2}\ T^8\ A^{+4}$

9. In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength λ. When the ion gets deexcited to the ground state in all possible ways (including intermediate emissions), a total of six spectral lines are observed. What is the value of λ ?

[Given : $h = 6.63 \times 10^{-34}$ Js; $c = 3 \times 10^8\ ms^{-1}$] s :

(1) 12.3 nm (2) 11.4 nm (3) 10.8 nm (4) 9.4 nm

Sol. **3**

$6 = \frac{n(n-1)}{2}$

$n = 4 = -0.85 \times 9$

$n = 3$

$n = 2$

$n = 1 = -13.6 \times 9$

$E = \frac{hc}{\lambda} = \frac{12400}{\lambda A^0} = 114.75$

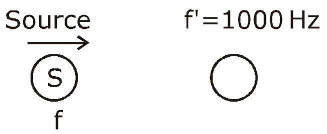
$\lambda = \frac{12400}{114.75} = 108.06A^0$

$= 10.8$ nm

10. A source of sound S is moving with a velocity of 50 m/s towards a stationary observer. The observer measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the source when it is moving away from the observer after crossing him ? (Take velocity of sound in air is 350 m/s)

(1) 857 Hz (2) 1143 Hz (3) 750 Hz (4) 807 Hz

Sol. **3**



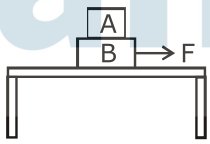
$$\frac{f' = f\left(\frac{350}{350-50}\right)}{f' = f\left(\frac{350}{350+50}\right)}$$

$$\frac{1000}{f''} = \frac{400}{3100}$$

$$f'' = \frac{3000}{4} = 0.150 \text{ Hz}$$

11. Two blocks A and B of masses $m_A = 1$ kg and $m_B = 3$ kg are kept on the table as shown in figure. The coefficient of friction between A and B is 0.2 and between B and the surface of the table is also 0.2. The maximum force F that can be applied on B horizontally, so that the block A does not slide over the block B is -

[Take $g = 10 \text{ m/s}^2$]



(1) 8 N (2) 16 N (3) 12 N (4) 40 N

Sol. **2**

$f_{2kg} = 2N$

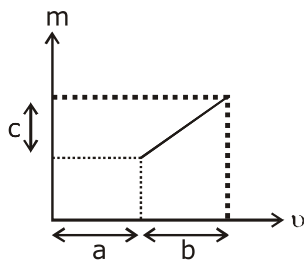
$a = 2 \text{ m/s}^2$

$f_{3kg} = 8N$

$F - 10 = 3 \times 2$

$F = 16$ N

12. The graph shows how the magnification m produced by a thin lens varies with image distance υ. What is the focal length of the lens used ?



(1) $\frac{b}{c}$ (2) $\frac{b^2}{ac}$ (3) $\frac{a}{c}$ (4) $\frac{b^2c}{a}$

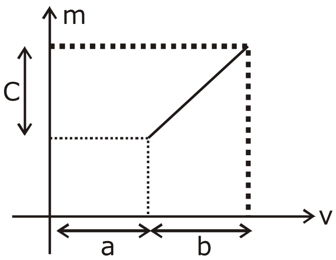
Sol. **1**

$m = \frac{f - V}{f} = 12 - \frac{V}{f}$

slope = $-\frac{1}{f}$

$-\frac{1}{f} = \frac{c}{b}$

$f = -\frac{b}{c}$



13. In a Young's double slit experiment, the ratio of the slit's width is 4 : 1. The ratio of the intensity of maxima to minima, close to the central fringe on the screen, will be -

(1) 25 : 9 (2) $\left(\sqrt{3}+1\right)^4$: 16 (3) 9 : 1 (4) 4 : 1

Sol. **3**

$\frac{I_1}{I_2} = \frac{4}{1}$

$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2$

$\frac{I_{max}}{I_{min}} = \left(\frac{9}{1}\right)$

14. In free space, a particle A of charge 1μC is held fixed at a point P. Another particle B of the same charge and mass 4 μg is kept at a distance of 1 mm from P. If B is released, then its velocity at a distance of 9 mm from P is -

$\left[\text{Take} \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 Nm^2C^{-2}\right]$

(1) 3.0×10^4 m/s (2) 1.5×10^2 m/s (3) 2.0×10^3 m/s (4) 1.0 m/s

Sol. **Bonus**

$\frac{k10^{-6} \times 10^{-6}}{10^{-3}} - \frac{k10^{-6} \times 10^{-6}}{9 \times 10^{-3}} = \frac{1}{2} \times 4 \times 10^{-6} \times 10^{-3} v^2$

$\frac{9 \times 10^9 \times 10^{-6}}{10^{-3}} - \frac{9 \times 10^9 \times 10^{-6}}{9 \times 10^{-3}} = 2 \times 10^3 v^2$

$9 \times 10^9 \times 10^{-6} - 10^9 \times 10^{-6} = 2 \times 10^{-6} v^2$

$4 \times 10^9 = v^2$

$v = \sqrt{40 \times 10^8}$

$v = \sqrt{40} \times 10^4$

15. A bullet of mass 20 g has an initial sped of 1 ms^{-1}, just before it starts penetrating a mud wall of thickness 20 cm. If the wall offers a mean resistance of 2.5×10^{-2} N, the speed of the bullet after emerging from the other side of the wall is close to -

(1) 0.3 ms^{-1} (2) 0.7 ms^{-1} (3) 0.1 ms^{-1} (4) 0.4 ms^{-1}

Sol. **2**

$w = k_f - k_i$

$-\frac{2\sqrt{5}}{10}\times 10^{-2} \times \frac{20}{100} = \frac{1}{2}\ mv_f^2 - \frac{1}{2}\ mv_1^2$

$-10^{-2} = m\ (v_f^2 - v_f^2)$

$-\ \frac{10^{-2}}{20\times 10^{-3}} = v_f^2 - 1$

$v_f^2 = 1 - \frac{10}{20} = 1.5$

$v_f = \sqrt{0.5} = 0.70$ m/sec

16. When heat Q is supplied to a diatomic gas of rigid molecules, at constant volume its temperature increases by ΔT. The heat required to produce the same change in temperature, at a constant pressure is -

(1) $\frac{5}{3}Q$ (2) $\frac{2}{3}Q$ (3) $\frac{3}{2}Q$ (4) $\frac{7}{5}Q$

Sol. **4**

$Q = \Delta U$

$Q = \frac{f}{2}\ nR\Delta T \qquad nR\Delta T = \frac{2Q}{f}$

$Q' = w + \frac{f}{2}\ nR\Delta T$

$Q' = nR\Delta T + \frac{f}{2}\ nR\Delta T$

$Q' = nR\Delta T\ (1 + f/2)$

$Q' = \frac{2Q}{f}\ (1 + f/2) = \frac{2Q}{5}\ (1 + 5/2)$

$Q' = \frac{2Q}{5} . \frac{7}{2} = \frac{7}{5}\ Q$

17. A submarine experiences a pressure of 5.05×10^6 Pa at a depth of d_1 in a sea. When it goes further to a depth of d_2, it experiences a pressure of 8.08×10^6 Pa. Then $d_2 - d_1$ is approximately (density of water = 10^3 kg/m^3 and acceleration due to gravity = 10 ms^{-2})

(1) 600 m (2) 300 m (3) 400 m (4) 500 m

Sol. **2**

$P_1 = \delta g d_1 + P_0$

$P_2 = \delta g d_2 + P_0$

$(P_2 - P_1) = \delta g\ (d_2 - d_1)$

$d_2 - d_1 = \frac{P_2 - P_1}{\delta g}$

$= \frac{8.08\times 10^6 - 5.05\times 10^6}{1000\times 10}$

$= \frac{3.03\times 10^6}{10^4} = 3.03 \times 10^2 = 300$ m

18. One mole of an ideal gas passes through a process where pressure and volume obey the relation $P = P_0\left[1 - \frac{1}{2}\left(\frac{V_0}{V}\right)^2\right]$. Here P_0 and V_0 are constants. Calculate the change in the temperature of the gas if its volume changes from V_0 to $2V_0$.

(1) $\frac{5}{4}\frac{P_0V_0}{R}$ (2) $\frac{1}{4}\frac{P_0V_0}{R}$ (3) $\frac{1}{2}\frac{P_0V_0}{R}$ (4) $\frac{3}{4}\frac{P_0V_0}{R}$

Sol. **1**

$PV = nRT$

$T = \frac{PV}{nR}$ n = 1 mole

$T = \frac{V}{R}\left[P_0\left[1 - \frac{1}{2}\left(\frac{V_0}{V}\right)^2\right]\right]$

$T_i = \frac{V_0}{R}\left[P_0\left[1 - \frac{1}{2}\left(\frac{V_0^2}{V^2}\right)\right]\right]$

$T_f = \frac{2V_0}{R}\left[P_0\left[1 - \frac{1}{2}\frac{V_0^2}{(2V_0)^2}\right]\right]$

$T_i = \frac{P_0V_0}{2R}$ $T_f = \frac{7}{4}\frac{P_0V_0}{R}$

$\therefore \Delta T = T_f - T_i$

$= \frac{7}{4}\frac{P_0V_0}{R} - \frac{P_0V_0}{2R} = \frac{5}{4}\frac{P_0V_0}{R}$

19. The time dependence of the position of a particle of mass m =2 is given by $\vec{r}(t) = 2t\hat{i} - 3t^2\hat{j}$. Its angular momentum, with respect to the origin, at time t = 2 is -

(1) $36\hat{k}$ (2) $48(\hat{i} + \hat{j})$ (3) $-34(\hat{k} - \hat{i})$ (4) $-48\hat{k}$

Sol. **4**

$L = m\ (\vec{r} \times \vec{v})$

$r = 2t\hat{i} - 3t^2\hat{j}$

at t = 2

$\vec{r} = 4\hat{i} - 12\hat{j}$

$\vec{v} = 2\hat{i} - 6t\hat{j} = 2\hat{i} - 12\hat{j}$

$\therefore L = 2\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & -12 & 0 \\ 2 & -12 & 0 \end{vmatrix} = -48\hat{k}$

20. The elastic limit of brass is 379 MPa. What should be the minimum diameter of a brass rod if it is to support a 400 N load without exceeding its elastic limit ?

(1) 1.00 mm (2) 1.16 mm (3) 1.36 mm (4) 0.90 mm

Sol. **2**

stan = F/A

$379 \times 10^6 = \frac{400}{\pi r^2}$

r = d/2

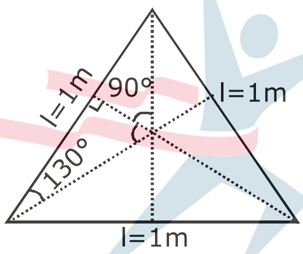
$379 \times 10^6 = \frac{400}{\pi \times \frac{d^2}{4}}$

$\therefore d^2 = \frac{1600}{379 \times 10^6 \times \pi}$

$d = \sqrt{\frac{1600}{379 \times 10^6 \times \pi}}$

21. The magnitude of the magnetic field at the center of an equilateral triangular loop of side 1m which is carrying a current of 10 A is -
[Take $\mu_0 = 4\pi \times 10^{-7}$ NA^{-2}]
(1) 9 μT (2) 18 μT (3) 3 μT (4) 1 μT

Sol. **2**



m due to single wine

$B = \frac{\mu_0}{4\pi d_1}$ (sin 60° + sin 60°)

$\therefore B_{net} = 3B_1$

$\left(\frac{3\mu_0}{4\pi \frac{l}{2\sqrt{3}}}(2\sin 60°)\right)$

$B = \frac{\mu_0 i}{4\pi d}$ ($\sin\theta_1 + \sin\theta_2$)

$= \frac{\mu_0 i(2\sqrt{3})}{4\pi l}$ [2 sin 60°]

= 18 μT Am

=

22. In an experiment, brass and steel wires of length 1m each with areas of cross section 1 mm^2 are used. The wires are connected in series and one end of the combined wire is connected to a rigid support and other end is subjected to elongation. The stress required to produce a net elongation of 0.2 mm is,
[Given, the Young's Modulus for steel and brass are, respectively, 120×10^9 N/m^2 and 60×10^9 N/m^2]
(1) 4.0×10^6 N/m^2 (2) 1.2×10^6 N/m^2 (3) 0.2×10^6 N/m^2 (4) 1.8×10^6 N/m^2

Sol. **Bonus**

$$y_w = \frac{\text{stream}}{\left(\frac{\text{Ol}}{\text{loop}}\right)}$$

$$\frac{2l}{y_w A} = \frac{l}{y_1 A} + \frac{l}{y_2 A}$$

$$y_w = \frac{2y_1 y_2}{(y_1 + y_2)}$$

$$\text{steam} = y_w \times \frac{\Delta l}{(l_1 + l_2)}$$

$= 8 \times 10^6$ N/m^2

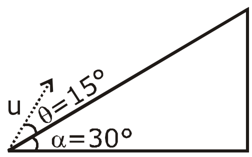
23. A spaceship orbits around a planet at a height of 20 km from its surface. Assuming that only gravitational field of the planet acts on the spaceship, what will be the number of complete revolutions made by the spaceship in 24 hours around the planet ?
[Given : mass of planet = 8×10^{22} kg, Radius of planet = 2×10^6 m, Gravitational constant G = 6.67×10^{-11} Nm^2/kg^2]
(1) 9 (2) 17 (3) 11 (4) 13

Sol. **3**

$$T = 2\pi\sqrt{\frac{(R_e + h)^3}{6m}}$$

$$T = 2\pi\left(\frac{(2 \times 10^6 + 2000)^3}{G \times M}\right)$$

24. A plane is inclined at an angle α = 30° with respect to the horizontal. A particle is projected with a speed u = 2 ms^{-1}, from the base of the plane, making an angle θ = 15° with respect to the plane as shown in the figure. The distance from the base, at which the particle hits the plane is close to -
(Take g = 10 ms^{-2})



(1) 18 cm (2) 20 cm (3) 14 cm (4) 26 cm

Sol. **2.**

$$R = \frac{2u^2 \sin\alpha \cos(\alpha + \beta)}{g\cos^2\beta}$$

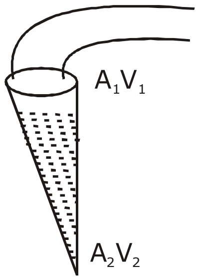
α = 15°
β = 30°
u = 2 m/s

25. Water from a tap emerges vertically downwards with an initial speed of 1.0 ms^{-1}. The cross-sectional area of tap is 10^{-4} m^2. Assume that the pressure is constant throughout the stream of water and that the flow is streamlined. The cross-sectional area of the stream, 0.15 m below the tap would be -

[Take g = 10 ms^{-2}]

(1) 1×10^{-5} m^2 (2) 5×10^{-5} m^2 (3) 5×10^{-4} m^2 (4) 2×10^{-5} m^2

Sol. **2**



$A_1v_1 = A_2v_2$

$1 \times 10^{-4} = A_2 \times \sqrt{1^2 + 2 \times g \times 0.15}$

$1 \times 10^{-4} = A_2 \times 2$

26. A 2mW laser operates at a wavelength of 500 nm. The number of photons that will be emitted per second is -

[Given Planck's constant h = 6.6×10^{-34} Js, speed of light c = 3.0×10^8 m/s)

(1) 5×10^{15} (2) 2×10^{16} (3) 1.5×10^{16} (4) 1×10^{16}

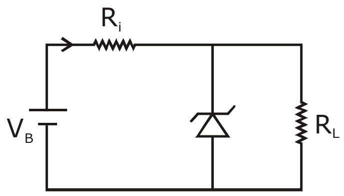
Sol. **1**

P = 2nw λ = 500 nm

$$n = \frac{IAt\lambda}{hc}$$

$$= \frac{10^{-9} \times 10^{34} \times 10^{-8}}{19.8} = \frac{10^{17}}{19.8}$$

27. The figure represents a voltage regulator circuit using a Zener diode. The breakdown voltage of the Zener diode is 6 V and the load ressitance is, R_L = 4kΩ. The series resistance of the circuit is R_i = 1 kΩ. If the battery voltage V_B varies from 8V to 16 V, what are the minimum and maximum values of the current through Zener diode ?

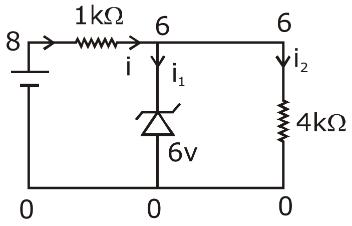


(1) 0.5 mA; 6 mA (2) 1 mA; 8.5 mA (3) 1.5 mA; 8.5 mA (4) 0.5 mA; 8.5 mA

Sol. **4**

V_2 = 6 volt

V_0 = 8 volt



$i = \frac{8-6}{1000} = \frac{2}{1000}$ = 2 ma

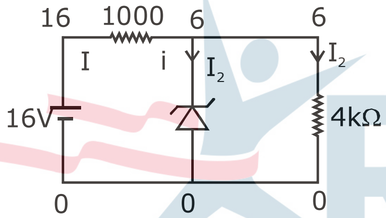
$i_2 = \frac{6}{4000}$ = 1.5 mA

$i = i_z + i_2$

$i_z = i - i_2$

= 2 – 15

= 0.5 mA



$i = \frac{16-6}{10^3}$ = 10 mA

i_2= 1.5 mA

i_2 = 10 – 1.56

= 8.5 mA

28. Two radioactive substances A and B have decay constants 5λ and λ respectively. At t = 0, a sample has the same number of teh two nuclei. The time taken for the ratio of the number of nuclei to become $\left(\frac{1}{e}\right)^2$ will be -

(1) 1/λ (2) 1/4λ (3) 1/2λ (4) 2/λ

Sol. **3**

$N_1 = N_0\ e^{-5\lambda t}$ ....(1)

$N_2 = N_0\ e^{-\lambda t}$ ....(2)

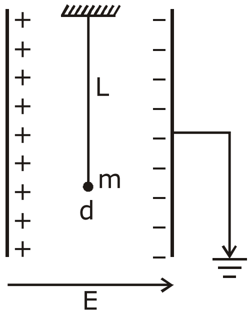
$$\frac{N_1}{N_2} = \frac{e^{-5\lambda t}}{e^{-\lambda t}}$$

$$\left(\frac{1}{e}\right)^2 = \frac{1}{e^{+4\lambda t}}$$

on solving we get

$$t = \frac{1}{2\lambda}$$

29. A simple pendulum of length L is placed between the plates of a parallel plate capacitor having electric field E, as shown in figure. Its bob has mass m and charge q. The time period of the pendulum is given by -



(1) $2\pi\sqrt{\dfrac{L}{\sqrt{g^2+\left(\dfrac{qE}{m}\right)^2}}}$ (2) $2\pi\sqrt{\dfrac{L}{\left(g-\dfrac{qE}{m}\right)}}$ (3) $2\pi\sqrt{\dfrac{L}{\left(g+\dfrac{qE}{m}\right)}}$ (4) $2\pi\sqrt{\dfrac{L}{\sqrt{g^2-\dfrac{q^2E^2}{m^2}}}}$

Sol. **1**

$g_{eff} = \sqrt{g^2+\left(\dfrac{qE}{m}\right)^2}$

$\therefore T = 2\pi\sqrt{\dfrac{l}{\sqrt{g^2+\left(\dfrac{qE}{m}\right)^2}}}$

30. Light is incident normally on a completely absorbing surface with an energy flux of 25 Wcm^{-2}. If the surface has an area of 25 cm^2, the momentum transferred to the surface in 40 min time duration will be -

(1) 3.5×10^{-6} Ns (2) 6.3×10^{-4} Ns (3) 5.0×10^{-3} Ns (4) 1.4×10^{-6} Ns

Sol. **3**

For Absorption

$F = \dfrac{IA}{C}$

$\dfrac{\Delta P}{\Delta T} = \dfrac{IA}{C}$

$\Delta P = \dfrac{IA \times \Delta t}{C}$

$\Delta p = \dfrac{25 \times 25 \times 40 \times 60}{3 \times 10^8}$

$= 5.0 \times 10^{-3}$ NS