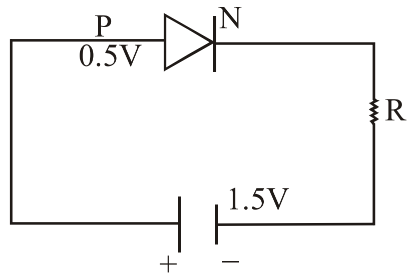
JEE MAIN SEP 2020 (MEMORY BASED) | 3RD Sep. SHIFT-1

Note: The answers are based on memory based questions which may be incomplete and incorrect.

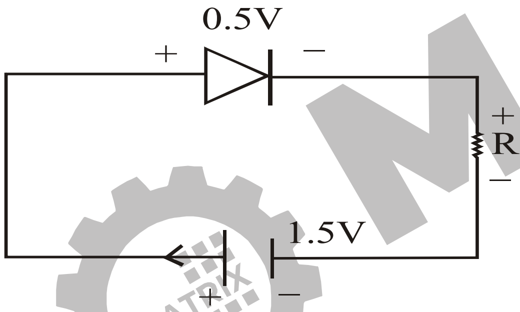
1. A PN junction diode when forward biased has drop of 0.5 V which is assumed to be idependent of current.The current in excess of 10mA throught the diode produces large joule heating which damages the diode. If we want to use a 1.5 V battery to forward bias the diode, the resistor used in series with the diode is



(1) 100Ω (2) 50Ω (3) 25Ω (4) 10Ω

Ans. (1)

Sol.



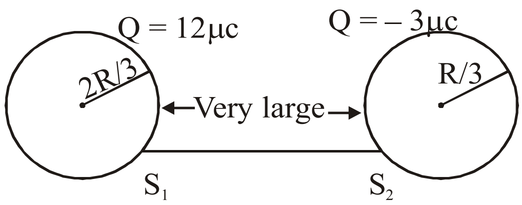
$V_{diode} = 0.5$ volt

$V_R = 1.5 - 0.5 = 1$ volt

$iR = 1$

$R = \frac{1}{i} = \frac{1}{10^{-2}} = 100\Omega$

2. A system consists of 2 isolated conducting spheres, kept at infinite distance. Sphere S_1 has radius $\frac{2R}{3}$ and charge 12μC and sphere S_2 has radius $\frac{R}{3}$ and charge –3μC. If the switch is closed, then find charges on S_1 & S_2.



(1) 3μC & 6μC (2) 4.5μC on both (3) 3μC & 3μC (4) 6μC & 6μC

Ans. (1)

Sol. Total charge = 12 – 3 = 9μC

Let final charges are q_1 & q_2

$$q_1 + q_2 = 9\mu C$$

and after connecting potential of S_1 & S_2 becomes same.

$$V_{S_1} = V_{S_2} \Rightarrow \frac{Kq_1}{\frac{2R}{3}} = \frac{Kq_2}{\frac{R}{3}}$$

$$\Rightarrow \frac{q_1}{q_2} = \frac{2}{1} \qquad .....(ii)$$

from (i) & (ii)

$\Rightarrow q_1 = 6\mu C$ & $q_2 = 3\mu C$

3. A uniform horizontal circular platform of mass 200kg is rotating at 5 rev/min. about a vertical axis passing through its centre. A boy of mass 80 kg is standing at its edge. If the boy moves to the centre of the platform, find out the final angular speed

(1) 3 rev/min (2) 6 rev/min (3) 9 rev/min (4) 12 rev/min

Ans. (3)

Sol. $M = 200kg$, $m = 80$ kg, $w_i = 5rpm$, $w_f = ?$

from angular momentum conservation,

$L_i = L_f$

$\Rightarrow I_i w_i = I_f w_f$

$$\Rightarrow \left[\frac{MR^2}{2} + mR^2\right]5\left[=\frac{MR^2}{2} + 0\right]w_f$$

$$\Rightarrow \left(\frac{200}{2} + 80\right)5 = \left(\frac{200}{2}\right)w_f$$

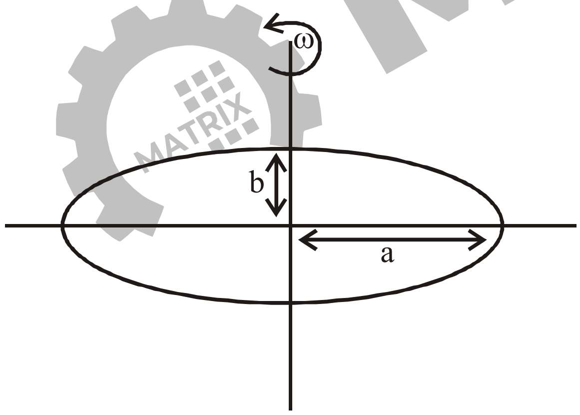
$$\Rightarrow w_f = \frac{180 \times 5}{100} = 9rpm$$

4. An elliptical ring of semi major and semi minor axis a and b respectively, rotates about diameter with angular speed ω in uniform magnetic field B. Resistance of elliptical ring R. Average rate of heat generated will be.

(1) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{2R}$ (2) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{4R}$ (3) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{3R}$ (4) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{R}$

Ans. (1)

Sol.



Area(A) = πab

$\phi = BA \cos\omega t$

$$\varepsilon = \frac{-d\phi}{dt} = AB\omega \cos\omega t$$

$$\langle P \rangle = \left\langle \frac{\varepsilon^2}{R} \right\rangle$$

$$= \left\langle \frac{A^2B^2\omega^2 \cos^2 wt}{R} \right\rangle$$

$$= \frac{A^2B^2\omega^2}{R}\left(\frac{1}{2}\right)$$

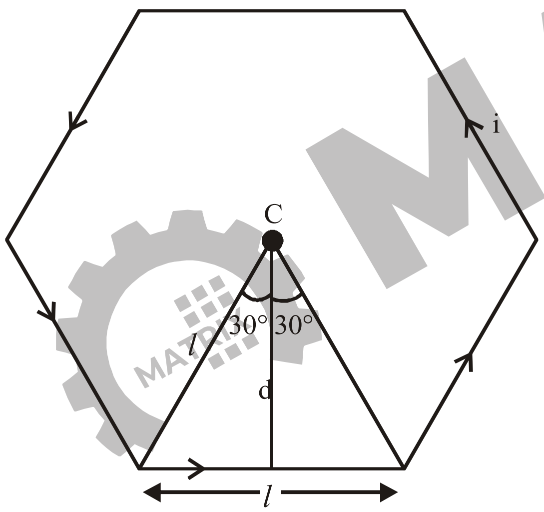
$$= \frac{\pi^2a^2b^2B^2}{R}\left(\omega^2\right)$$

5. Magnetic field at centre of hexagonal coil having 50 turns, side 10 cm and current i in the units of $\frac{\mu_0 I}{\pi}$.

(1) $500\sqrt{3}$ (2) $50\sqrt{3}$ (3) 50 (4) 100

Ans. (1)

Sol.



$$\cos 30 = \frac{d}{l}$$

$$\Rightarrow d = \frac{\sqrt{3}}{2} l$$

$l = 0.1\text{m}$

$$B_C = 50\left[6\times\frac{\mu i}{4\pi\left(\frac{\sqrt{3}l}{2}\right)}(\sin 30^\circ + \sin 30^\circ\right]$$

$$= 300\frac{\mu oi}{2\sqrt{3}\pi l}\left(2\times\frac{1}{2}\right) = \frac{150}{\sqrt{3}}\frac{\mu oi}{\pi l}$$

$$= 500\sqrt{3}\frac{\mu_0 i}{\pi}$$

6. If equation of a electromagnetic wave is $B = 3\sin\frac{2\pi}{T}(y+ct)\,\hat{i}$ then find out the amplitude of electric field

Ans. $9 \times 10^8\ \frac{N}{C}$

Sol. $E_0 = B_0C = 3 \times (3 \times 10^8) = 9 \times 10^8\ \frac{N}{C}$

7. A planet revolving around earth at height 'R' (Radius of earth). When a rocket is fired from planet its velocity increases to $\sqrt{\frac{3}{2}}$ times. Find final orbital radius of planet.

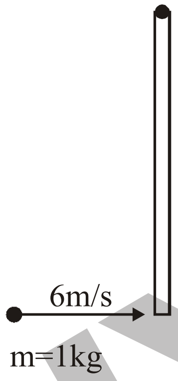
Sol. Initial orbital velocity $\Rightarrow V_0 = \sqrt{\frac{GM}{R+R}} = \sqrt{\frac{GM}{2R}}$

Final orbital velocity $\Rightarrow V' = \sqrt{\frac{3}{2}}V_0$

$$\Rightarrow \sqrt{\frac{GM}{r}} = \sqrt{\frac{3}{2}}\sqrt{\frac{GM}{2R}}$$

$$\Rightarrow r = \frac{4R}{3}$$

8. A particle of mass m moving with velocity u on a frictionless surface collide with the rod of mass M = 2kg, length = 1m as shown in the figure. After collision particle stricks with rod. Rod is hinged at upper end and is vertical before collision find maximum angle rotated by rod in vertical plane after collision. Find the maximum angle (θ°) rotated by rod in vertical plane after collision.



(1) 63°

(2) 69°

(3) 53°

(4) 59°

Ans. (1)

Sol. ∴ Angular impluse on the system (Rod + Particle) about Hinge is zero during collision.

$\therefore L_i = L_f$

$$\Rightarrow mul = \left(\frac{Ml^2}{3} + ml^2\right) w$$

$$\Rightarrow 1 \times 6 \times 1 = \left[\frac{2 \times (1)^2}{3} + 1(1)^2\right]^{\omega}$$

$$\Rightarrow \omega = \frac{18}{5}\frac{\text{Red}}{\text{see}}$$

Let Rod rotates upto angle θ.

From energy conservation

$$\frac{1}{2}\left(\frac{Ml^2}{3} + ml^2\right)\omega^2 = mgl(1-\cos\theta) + \frac{Mgl}{2}(1-\cos\theta)$$

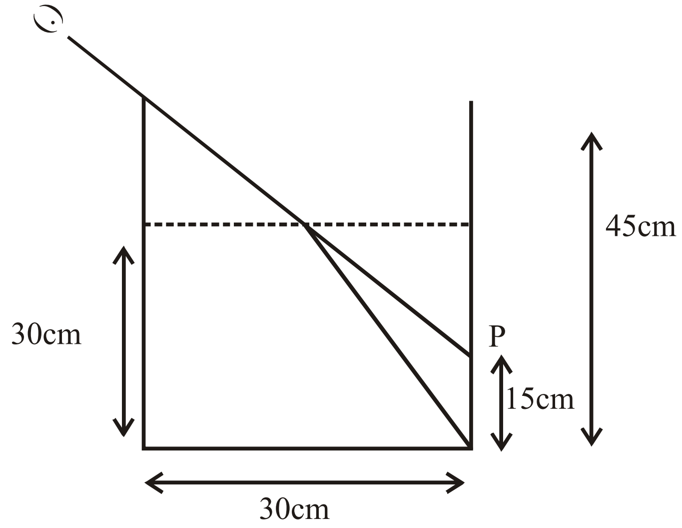
$$\Rightarrow \frac{1}{2}\left(\frac{2}{3}+1\right)\left(\frac{18}{5}\right)^2 = (1-\cos\theta)\left[(1)10\times1 + \frac{2\times10\times1}{2}\right]$$

$\Rightarrow 1 - \cos\theta = 0.54$

$\Rightarrow \cos\theta = 0.46$

$\Rightarrow \cos\theta \approx 63^o$

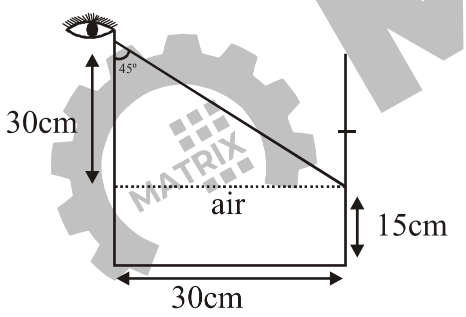
9. An observer's line of sight is at P, when container of diameter 30 cm and height 45 cm is empty. If this container is filled with a liquid up to 30 cm height he is able to see the edge of container. Find refractive index of liquid.



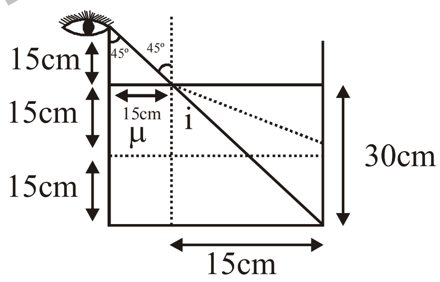
(1) $\sqrt{\frac{5}{2}}$ (2) $\frac{5}{\sqrt{2}}$ (3) $\frac{\sqrt{5}}{2}$ (4) $\frac{5}{2}$

Ans (1)

Sol.



(Before filling)



(after filling water)

$\tan i = \frac{15}{30} = \frac{1}{2}$

$\sin i = \frac{1}{\sqrt{15}}$

and from snell's law : -

(i) $\sin 45° = \mu \sin i \Rightarrow \mu = \frac{\sin 45°}{\sin i} = \sqrt{\frac{5}{2}}$

10. If the wavelength of incident radiation changes from 500 nm to 200 nm, then the maximum kinetic energy increase to three times. Find the work function.

(1) 0.62 (2) 0.65 (3) 0.50 (4) 0.52

Ans. (1)

Sol. $K_{max} = \frac{hc}{\lambda} - \phi$

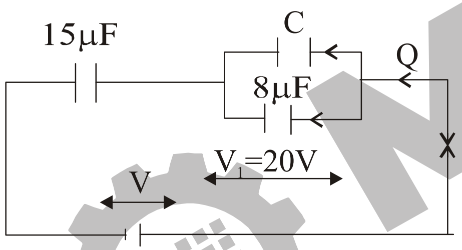
$$\therefore \frac{k_1}{k_2} = \frac{\frac{hc}{\lambda_1} - \phi}{\frac{hc}{\lambda_2} - \phi} \Rightarrow \frac{k}{3k} = \frac{\frac{1240}{500} - \phi}{\frac{1240}{200} - \phi}$$

$\Rightarrow 6.2 - \phi = 3\,(2.48 - \phi)$

$\Rightarrow 2\phi = 7.44 - 6.2 = 1.24$

$\Rightarrow \phi = 0.62$ ev

11.

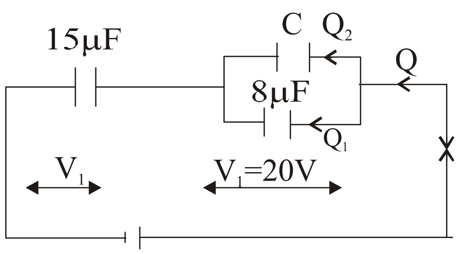


If total charge supplied by battery is 750μC. Find charge on 'C' ?

(1) 160 (2) 590 (3) 450 (4) 630

Ans. (2)

Sol.

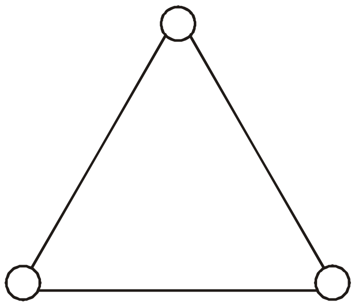


$Q_1 + Q_2 = 750\ \mu c$

$Q_1 = 8 \times 20 = 160\ \mu c$

$\therefore Q_2 = 750 - 160 = 590\ \mu c$

12. A triatomic molecule in the shape of a triangle can be assumed that atoms are at vertices of triangle and joined by mass less rods. Internal energy of 1 mole at temperature T is :



(1) 3RT (B) 3/2RT (C) 11/RT (D) 5/2RT

Ans. (1)

Sol. Degree of freedom for non-linear triatomic molecule = 6

$\therefore$ Internal energy $= \frac{f}{2}RT = \frac{6}{2}RT = 3RT$

13. Pressure inside two soap bubbles is 1.01 and 1.02 atmosphere. The ratio between their volume is:

(1) 8 : 1 (2) 4 : 1 (3) 2 : 1 (4) 3 : 1

Ans. (1)

Sol. Excess pressure (Δp)= Pressure inside – Atmospheric pressure

$$\therefore \frac{\Delta P_1}{\Delta P_2} = \frac{\frac{4T}{R_1}}{\frac{4T}{R_2}}$$

$$\Rightarrow \frac{R_2}{R_1} = \frac{1.01-1}{1.02-1} = \frac{0.01}{0.02} = \frac{1}{2}$$

$$\text{So } \frac{V_1}{V_2} = \left(\frac{R_1}{R_2}\right)^3 = \left(\frac{2}{1}\right)^3 = \frac{8}{1}$$

14. A 750Hz, 20V source is connected to a resistance of 100Ω, an inductance of 0.1803H and a capacitance of 10μF all in series. Calculate the time in which the resistance (thermal capacity 2J/°C) will get heated by 10° C (Ignore radiation)

(1) 6.8 min (2) 5.8 min (3) 7.8 min (4) 9.8 min

Ans. (2)

Sol. Heat required $Q = ms\,\Delta T = 2 \times 10 = 20$ Joule

$\omega = 2\pi \times 750 = 1500\pi$, $X_L = \omega l = 1500\pi \times 0.1803 = 849.2\ \Omega$

$$X_C = \frac{1}{\omega c} = \frac{10^6}{1500\pi \times 10} = 21.2\Omega$$

$$i = \frac{V}{Z} = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{20}{\sqrt{(100)^2 + (828)^2}} = \frac{20}{834}$$

and $Q = i^2 Rt$

$$\Rightarrow 20 = \left(\frac{20}{834}\right)^2 \times 100 \times t$$

$\Rightarrow t = 348$ sec $= 5.8$ min

15. A mass of 2 kg suspended by a string of mass 6 kg. A wave of wavelength 6cm is produced at the bottom of string. The wavelength of wave at the top end of string will be.

(1) 6cm (2) 18 cm (3) 12cm (4) 24 cm

Ans. (3)

Sol. $V \propto \lambda$

$$\frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2}$$

$$\lambda_2 = \frac{V_1}{V_2}\lambda_1 = \sqrt{\frac{T_2}{T_1}} \quad T_2 = 8g \text{ (Top)}$$

$$\sqrt{\frac{8g}{2g}}\lambda_1 \qquad T_1 = 2g \text{ (Bottom)}$$

$= 2\lambda_1 = 12$cm

16. Screw gauge of pitch 0.1 cm and 50 division on circular scale. measure thickness of an object. Which of the following measurement is possible for thickness

(1) 2.123 cm (2) 2.124 cm (3) 2.125 cm (4) 2.127 cm

Ans. (2)

Sol. Thick ness = M.S. Readin + Circular Scale Readin (L.C.)

Here, $LC = \frac{0.1}{50} = 0.002$ cm per division

17. A bowling machine projects a ball of mass 0.15 kg in upward direction. If ball displaced along bowling machine 0.2m and released. After the released from bowling machine ball attain 20 m height then find the force exerted by bowling machine on the ball.

(1) 145.5N (2) 165.5N (3) 175.5 N (4) 151.5N

Ans. (4)

Sol. Total height attained by a ball after release = 20 + 0.2 = 20.2m

From work energy theorem,

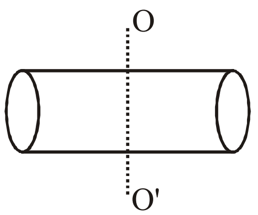
$w_F + w_g = \Delta K$

$F(0.2) - mg(20.2) = 0$

$F = mg\frac{(20.2)}{0.2}$

$= 151.5$ N

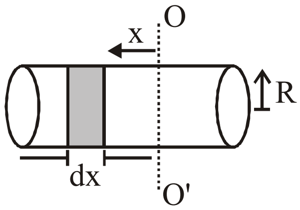
18. For a given volume of solid cylinder, find the ratio $\frac{\ell}{R}$ such that moment of inertia of cylinder about axis OO' will be maximum



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

Ans. (1)

Sol. Let mass of cylinder is M, length = L & radius = R.Take elementary disc of radius R and thickness dx at a distance of x from axis OO’ then moment of inertia about OO’ as this element



$$dI = \frac{dmR^2}{4} + dmx^2$$

$$I = \int dI = \int \frac{dmR^2}{4} + \int_{n=L/2}^{n=L/2} \frac{M}{L} x^2 dx$$

$$I = \frac{MR^2}{4} + \frac{ML^2}{12}$$

$$I = \frac{M}{4} \times \frac{V}{\pi L} + \frac{ML^2}{12}$$

$$\frac{dI}{dL} = -\frac{mV}{4\pi L} + \frac{M \times 2L}{12} = 0$$

$$\Rightarrow V = \frac{2}{3}\pi L^3$$

$$\Rightarrow \pi R^2 L = \frac{2}{3}\pi L^3$$

$$\Rightarrow \frac{L}{R} = \sqrt{\frac{3}{2}}$$

19. Energy of electron in its nth orbit is given as $\left(E_n = \frac{13.6}{n_2} \times z\right)eV$. Consider a hydrogen atom, find the amount of energy needed to transfer electron from 1st orbit to 3rd orbit :

(1) 13.6 eV (2) 1.51 eV (3) 3.4 eV (4) 12.09 eV

Ans. (4)

Sol. For hydrogen Z = 1

Energy of 1st orbit = $E_1 = -\frac{13.6}{12} eV = -13.6eV$

Energy of 3rd orbit = $E_3 = -\frac{13.6}{12} eV = -1.51eV$

Energy difference $\Delta E = E_3 - E_1 = 12.09eV$

20. An external pressure P is applied on a cube at 273K. Hence it compresses equally from all sides, α is the coefficient of linear expansion & K is the bulk modulus of material. To bring the cube to its original size by heating, the temperature must be

(1) $\frac{P}{3\alpha k}$ (2) $\frac{P}{\alpha k}$ (3) $\frac{P}{2\alpha k}$ (4) $\frac{P}{4\alpha k}$

Ans. (1)

Sol. As we know :

$$K = \frac{P}{\Delta v / v} = \left(\frac{\Delta v}{v}\right)_1 = \frac{P}{k}$$

& due to thermal expansion

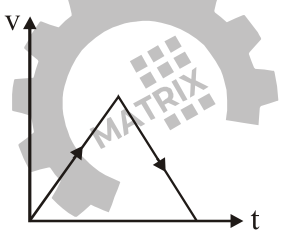
$$\left(\frac{\Delta v}{v}\right)_2 = \gamma \Delta T = 3\alpha \Delta T$$

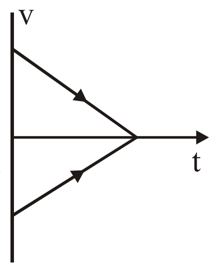
$\Rightarrow \left(\frac{\Delta v}{v}\right)_1 + \left(\frac{\Delta v}{v}\right)_2 = 0$ for shape which is restoring.

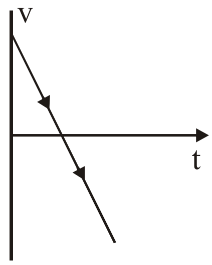
$$\Rightarrow \frac{-P}{K} + 3\alpha \Delta T = 0$$

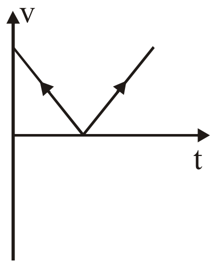
$$\Delta T = \frac{P}{3\alpha K}$$

21. A body is shown vertically upwards. Which graph represents the variation of velocity wrt time ?

(1) 

(2) 

(3) 

(4) 

Ans. (3)

Sol. Let us take upward direction as positive.

Initial velocity = u

acceleration = – g

Using v = ut + at v = u – gt

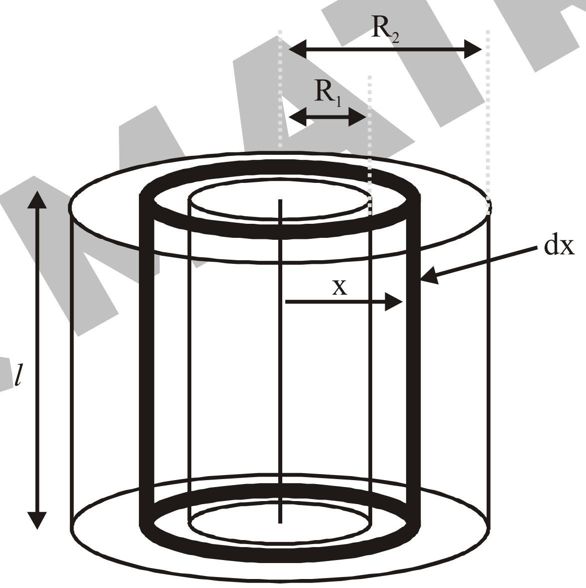
Straight line curve with (– ve) slope. Hence answer is (3)

22. The cylinderical shell of length l and inner and outer radius R_1 and R_2 respectively. Find resistance of cylinder if current flows radially outward in the cylinder. Resistivity of material of cylinder is ρ.

(1) $\frac{\rho}{\pi l} ln \frac{R_2}{R_1}$ (2) $\frac{\rho}{4\pi l} ln \frac{R_2}{R_1}$ (3) $\frac{\rho}{3\pi l} ln \frac{R_2}{R_1}$ (4) $\frac{\rho}{2\pi l} ln \frac{R_2}{R_1}$

Ans. (4)

Sol.



The ressistance of small element

$$\Delta R = \frac{\rho dr}{2\pi r \ell}$$

$$R = \frac{\rho}{2\pi \ell}\int_{R_1}^{R_2} \frac{dr}{r}$$

$$R = \frac{\rho}{2\pi \ell} \ell n \frac{R_2}{R_1}$$

23. $1\mu C$ charge moves with the velocity $\hat{v} = 4\hat{i} + 6\hat{j} + 3\hat{k}$ in uniform magnetic field. $\hat{B} = 3\hat{i} + 4\hat{j} - 3\hat{k} \times 10^{-3}$.

Force experience by charged particle in units of 10^{-9} N will be :

(1) $-0.3\hat{i} + 2.1\hat{j} + 0.4\hat{k}$ (2) $-30\hat{i} + 21\hat{j} - 2\hat{k}$

(3) $-0.03\hat{i} + 0.21\hat{j} + 0.04\hat{k}$ (4) $-3\hat{i} + 0.21\hat{j} + 0.4\hat{k}$

Ans. (2)

Sol. $F = 10^6 \times 10^3 \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 4 & 6 & 3 \\ 3 & 4 & -3 \end{vmatrix}$

$= 10^9 \left[\hat{i}(-30) - \hat{j}(-12-9) + \hat{k}(16-18) \right]$

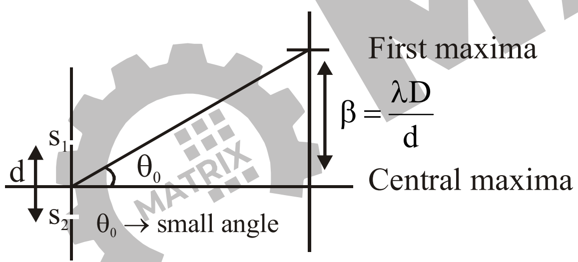
$= 10^9 \left[-30\hat{i} + 21\hat{j} - 2\hat{k} \right]$

24. In YDSE wavelength of light used is 500 nm and slit width is 0.05 nm. then the angular fringe width will be :

(1) 1.8° (2) 3.2° (3) 0.57° (4) 0.48°

Ans. (3)

Sol.



Angular fringe width, $\theta_0 \approx \tan\theta_0 = \frac{\beta}{D}$

$\theta_0 = \frac{\lambda}{d} = \frac{500 \times 10^9}{5 \times 10^5} = 10^{-2}$ Radian $= 0.57°$

25. A radioactive sample remains undecayed $\frac{9}{16}$ after time t. How much sample remains undecayed after time $\frac{t}{2}$.

(1) $\frac{3}{4}$ (2) $\frac{9}{16}$ (3) $\frac{4}{3}$ (4) $\frac{16}{9}$

Ans. (1)

Sol. $N = N_0 e^{-\lambda t}$ ....(1)

$N' = N_0 e^{lt/2}$ ....(2)

Form (1) & (2)

$$\left(\frac{N'}{N_0}\right) = \left(\frac{N}{N_0}\right)^{\frac{1}{2}} = \left(\frac{9}{16}\right)^{\frac{1}{2}} = \frac{3}{4}$$