Moving Charges and Magnetism

Question1

Two thin long parallel wires separated by a distance ' r ' from each other in vacuum carry a current of I ampere in opposite directions. Then, they will

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Options:

A. Attract each other with a force per unit length of $\frac{\mu_0 I^2}{2\pi r}$

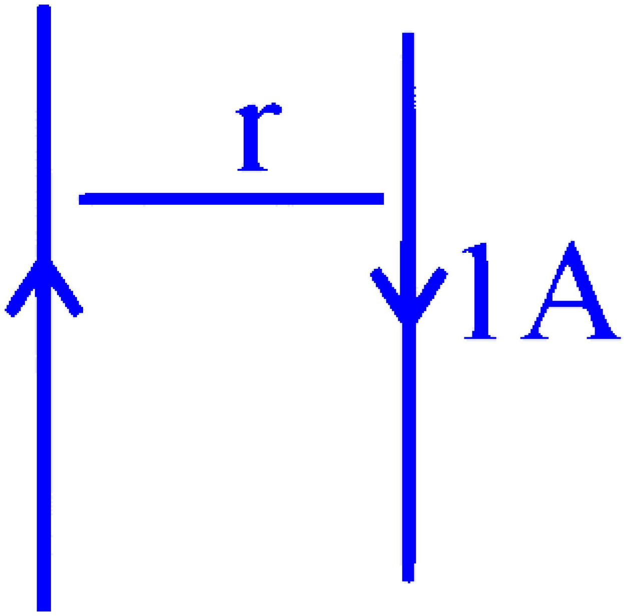
B. Repel each other with a force per unit length of $\frac{\mu_0 I^2}{2\pi r}$

C. Repel each other with a force per unit length of $\frac{\mu_0 I^2}{2\pi r^2}$

D. Attract each other with a force per unit length of $\frac{\mu_0 I^2}{2\pi r^2}$

Answer: B

Solution:



$\frac{f}{\ell} = \frac{\mu_0 i, i_2}{t\pi r}$

If they carry opposite currently they repeat each other

Question2

A solenoid is 1 m long and 4 cm in diameter. It has five layers of windings of 1000 turns each and carries a current of 7A. The magnetic field at the centre of the solenoid is

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Options:

A. 0.4396×10^{-5} T

B. 4.396×10^{-2} T

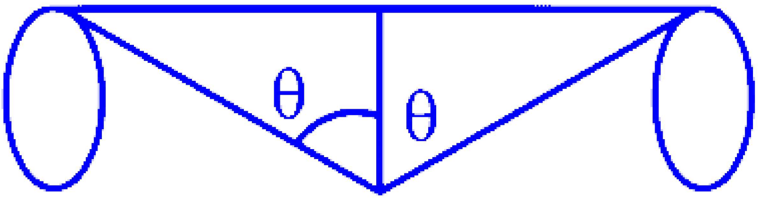
C. 43.96×10^{-2} T

D. 439.6 T

Answer: B

Solution:

$\ell = 1 \text{ m}; \text{r} = 2 \text{ cm}; \text{N} = 5000; \text{t} = 7 \text{ A}; \sin\theta \approx 1$



$\text{B} = \frac{\mu_0 \text{Ni}}{\ell} \sin\theta$

$$B = \frac{4\pi \times 10^{-7} \times 5000 \times 7 \times 1}{1}$$
$$B = 4.396 \times 10^{-2} \text{ T}$$

Question3

Identify the correct statement

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Options:

A. A current carrying conductor produces an electric field around it.

B. A straight current carrying conductor has circular magnetic field lines around it.

C. The direction of magnetic field due to a current element is given by Flemings Left Hand Rule

D. The magnetic field inside a solenoid is non-uniform

Answer: B

Solution:

The correct statement is Option B:

• Option B

A straight current-carrying conductor has circular magnetic field lines around it.

Why the others are incorrect:

Option A

A neutral, current-carrying wire does not produce an electric field around it (externally it remains electrically neutral).

Option C

Fleming's Left-Hand Rule gives the direction of force on a current in an external magnetic field, not the field created by the current itself. The field around a straight conductor follows the Right-Hand Thumb Rule.

Option D

Inside a long, closely wound solenoid the magnetic field is essentially uniform along its length.

Question4

Which of the following graphs represents the variation of magnetic field B with perpendicular distance ' r ' from an infinitely long, straight conductor carrying current?

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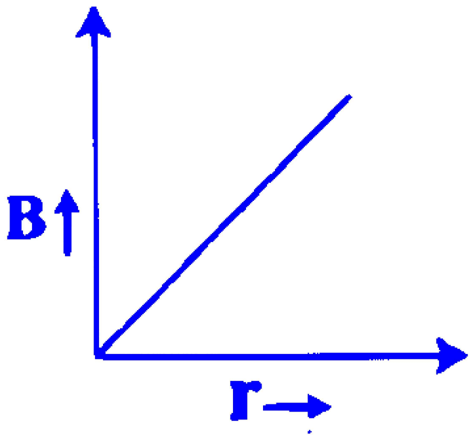
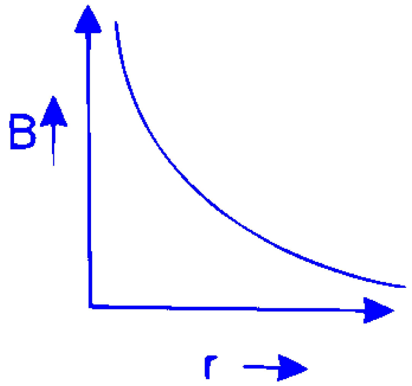
Options:

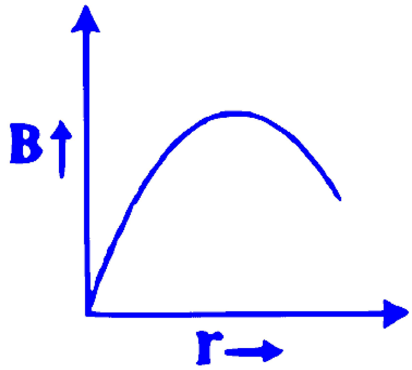
A.



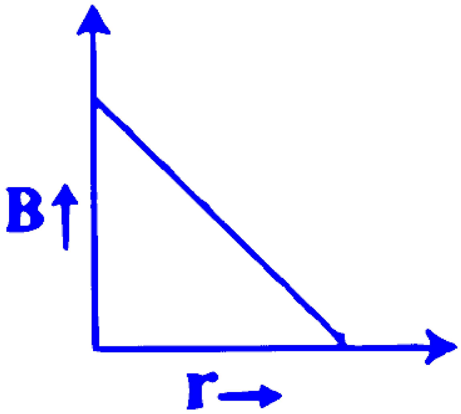
B.



C.



D.



Answer: B

Solution:

The magnetic field B around an infinitely long, straight conductor carrying a steady current can be described using the equation:

$B = \frac{\mu_0 i}{2\pi r}$

where:

B is the magnetic field,

μ_0 is the permeability of free space,

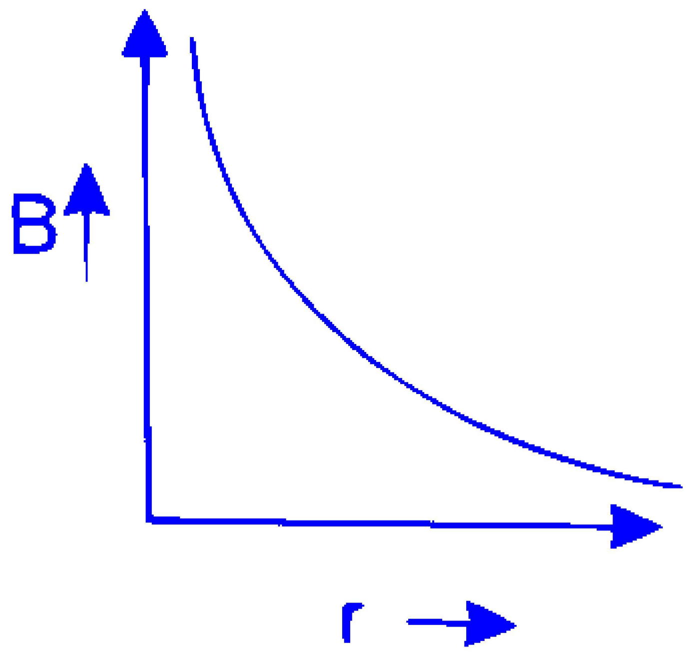
i is the current through the conductor, and

r is the perpendicular distance from the conductor.

From this equation, we can see that B is inversely proportional to r, which implies:

$B \propto \frac{1}{r}$

This relationship is characteristic of a rectangular hyperbola, meaning the graph of magnetic field B versus distance r will form a hyperbolic shape.



Question5

A square loop of side 2 m lies in the Y-Z plane in a region having a magnetic field $\vec{B} = (5\hat{i} + 3\hat{j} - 4\hat{k})T$. The magnitude of magnetic flux through the square loop is

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Options:

A. 20 Wb

B. 12 Wb

C. 16 Wb

D. 10 Wb

Answer: A

Solution:

To find the magnetic flux through a square loop of side 2 meters that lies in the Y-Z plane, given the magnetic field $\overrightarrow{B} = (5\hat{i} + 3\hat{j} - 4\hat{k})$ T, we proceed as follows:

Determine the area vector:

Since the loop is in the Y-Z plane, its area vector $\overline{A}$ is perpendicular to this plane and points along the X-axis. The magnitude of the area vector is given by the area of the square, which is $2 \times 2 = 4$ square meters. The area vector is thus $\overline{A} = 4\hat{i}$.

Calculate the magnetic flux:

The magnetic flux ϕ through the loop is given by the dot product of the magnetic field $\overline{B}$ and the area vector $\overline{A}$:

$$\phi = \overline{B} \cdot \overline{A} = (5\hat{i} + 3\hat{j} - 4\hat{k}) \cdot 4\hat{i}$$

Performing the dot product, we have:

$$\phi = (5 \times 4) + (3 \times 0) + (-4 \times 0) = 20\,\text{Wb}$$

Thus, the magnitude of the magnetic flux through the square loop is $20\,\text{Wb}$.

Question6

A moving electron produces

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Options:

A. only electric filed

B. both electric and magnetic-field

C. only magnetic field

D. neither electric nor magnetic field

Answer: B

Solution:

A moving electron produces electric field and magnetic field both, while static charge produces only electric field.

Question7

A coil having 9 turns carrying a current produces magnetic field B_1 at the centre. Now the coil is rewounded into 3 turns carrying same current. Then, the magnetic field at the centre $B_2 =$

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Options:

A. $B_1/9$

B. $9B_1$

C. $3B_1$

D. $B_1/3$

Answer: A

Solution:

Case - I

Number of turns, $N_1 = 9$

$\therefore$

$\therefore B_1 = \frac{\mu_0 N_1 I}{2R} = \frac{9\mu_0 I}{2R}$

Case-II $N_2 = 3$

If radius of turns be R', then

$9 \times 2\pi R = 3 \times 2\pi R'$

$\Rightarrow \quad R' = 3R$

$\therefore \quad B_2 = \frac{\mu_0 N_2 I}{2R'} = \frac{\mu_0 \times 3 \times I}{2 \times 3R} = \frac{\mu_0 I}{2R}$

$\therefore \quad \frac{B_2}{B_1} = \frac{\frac{\mu_0 I}{2R}}{\frac{9\mu_0 E}{2R}} = \frac{1}{9} \Rightarrow B_2 = \frac{B_1}{9}$

Question8

A particle of specific charge $q/m = \pi \mathrm{Ckg}^{-1}$ is projected the origin towards positive X-axis with the velocity $10 \mathrm{~ms}^{-1}$ in a uniform magnetic field $\mathbf{B} = -2\mathbf{k}\hat{T}$. The velocity v of particle after time $t = \frac{1}{12}$ s will be (in ms^{-1})

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Options:

A. $5(\hat{\mathbf{i}} + \hat{\mathbf{j}})$

B. $5(\hat{\mathbf{i}} + \sqrt{3\mathrm{j}})$

C. $5(\sqrt{3}\mathbf{i} - \hat{\mathbf{j}})$

D. $5(\sqrt{3i} + \hat{j})$

Answer: D

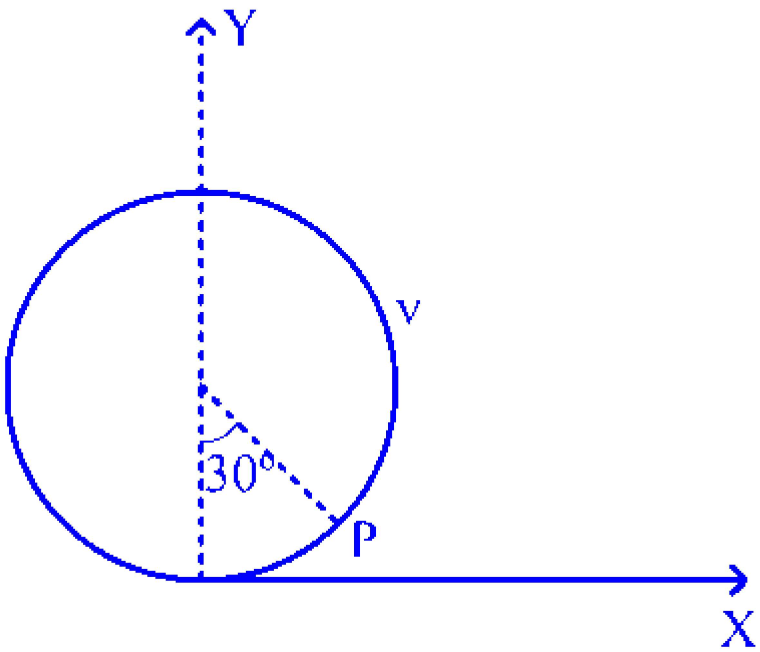
Solution:

We know that time period, $T = \frac{2\pi m}{qB} = \frac{2\pi}{\frac{q}{m}B} 1$ s

Since, the particle will be at point P after time,

$t = \frac{1}{12}$ s $= \frac{T}{12}$ s

It will be deviated by an angle, $\theta = 2\pi/12 = 30^{\circ}$



Hence, velocity at point P,

$$\mathbf{v} = 10\left(\cos 30^{\circ}\hat{\mathbf{i}} + \sin 30^{\circ}\hat{\mathbf{j}}\right)$$
$$= 10\left(\frac{\sqrt{3}}{2}\hat{\mathbf{i}} + \frac{1}{2}\hat{\mathbf{j}}\right) = 5(\sqrt{3\hat{i}} + \hat{\mathbf{j}})$$

Question9

The magnetic field at the centre of a circular coil of radius R carrying current I is 64 times the magnetic field at a distance x on its axis from the centre of the coil. Then, the value of x is

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Options:

A. $\frac{R}{4}\sqrt{15}$

B. $R\sqrt{3}$

C. $\frac{R}{4}$

D. $R\sqrt{15}$

Answer: D

Solution:

The magnetic field at the center of a circular coil with radius R carrying a current I is given by:

$$B_{\text{center}} = \frac{\mu_0 I}{2R}$$

where μ_0 is the permeability of free space.

The magnetic field at a distance x on the axis from the center of the coil is given by:

$$B_x = \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$$

According to the problem, the field at the center is 64 times the field at distance x:

$$B_{\text{center}} = 64 B_x$$

Substituting the expressions for B_{center} and B_x, we get:

$$\frac{\mu_0 I}{2R} = 64 \cdot \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$$

Simplifying, and cancelling out common terms, we have:

$$\frac{1}{R} = 64 \cdot \frac{R^2}{(R^2+x^2)^{3/2}}$$

Rearranging gives:

$$(R^2 + x^2)^{3/2} = 64R^3$$

Taking the cube roots on both sides:

$$R^2 + x^2 = (64R^3)^{2/3}$$

Calculating the right-hand side:

$$R^2 + x^2 = 64^{2/3} R^2$$

Since $64 = 4^3$, we can simplify $64^{2/3}$ as:

$$64^{2/3} = 4^2 = 16$$

So the equation becomes:

$$R^2 + x^2 = 16R^2$$

Therefore:

$$x^2 = 15R^2$$

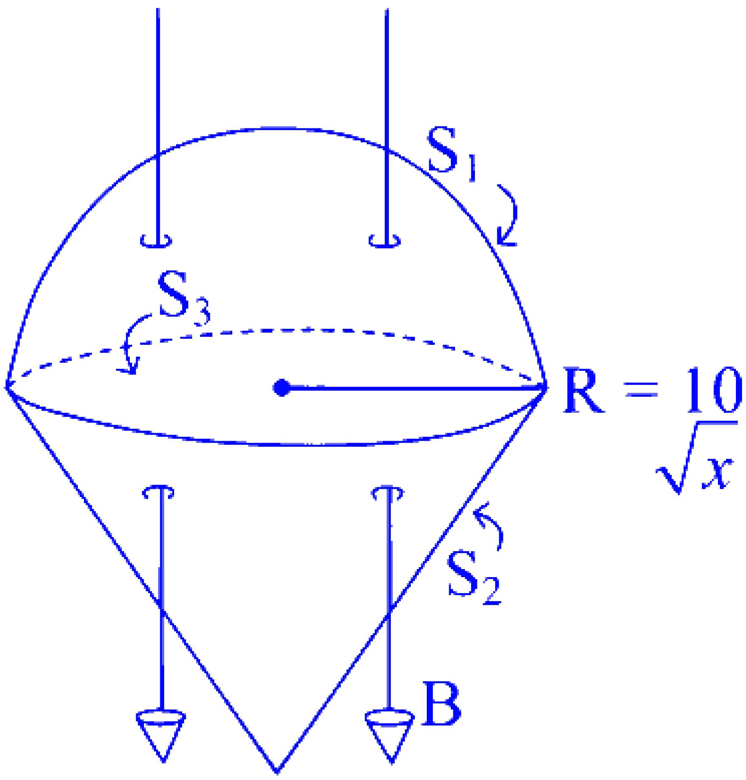
Thus, the value of x is:

$$x = R\sqrt{15}$$

The correct answer is **Option D:** $R\sqrt{15}$.

Question10

A uniform magnetic field of strength $B = 2\text{mT}$ exists vertically downwards. These magnetic field lines pass through a closed surface as shown in the figure. The closed surface consists of a hemisphere S_1, a right circular cone S_2 and a circular surface S_3. The magnetic flux through S_1 and S_2 are respectively.



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Options:

A. $\Phi_{S_1} = -20\mu \text{ Wb}, \Phi_{S_2} = +20\mu \text{ Wb}$

B. $\Phi_{S_1} = +20\mu \text{ Wb}, \Phi_{S_2} = -20\mu \text{ Wb}$

C. $\Phi_{S_1} = -40\mu \text{ Wb}, \Phi_{S_2} = +40\mu \text{ Wb}$

D. $\Phi_{S_1} = +40\mu \text{ Wb}, \Phi_{S_2} = -40\mu \text{ Wb}$

Answer: A

Solution:

Given,

$B = 2\text{mT}$

$= 2 \times 10^{-3}\ \text{T}, R = \dfrac{10}{\sqrt{\pi}}\ \text{cm}$

Magnetic flux passing through surface S_1,

$\phi_{S_1} = BS_1 \cos 180^\circ$

$= 2 \times 10^{-3} \times \pi R^2 (-1)$

$= -2 \times 10^{-3} \times \pi \times \dfrac{100}{\pi} \times 10^{-4}$

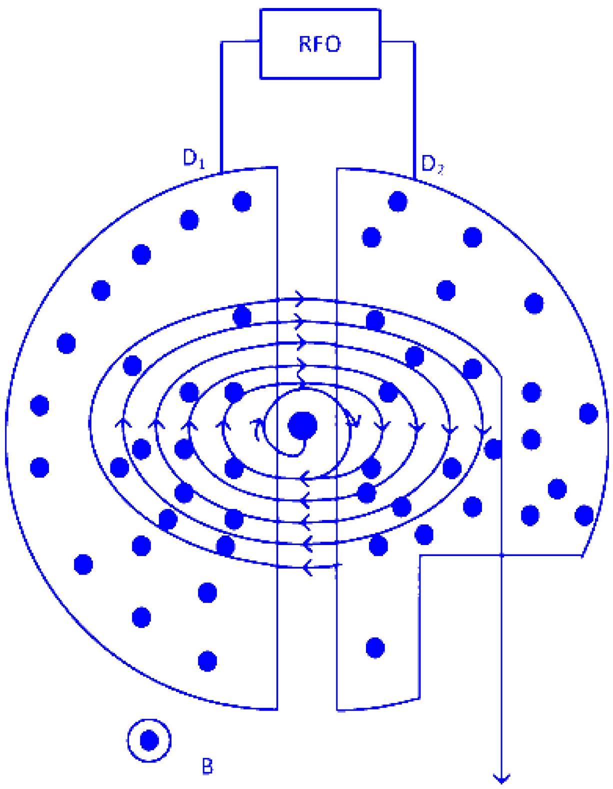
$= -20 \times 10^{-6}\ \text{Wb} = -20\mu\ \text{Wb}$

Since, Total entering magnetic flux = Total leaving magnetic flux

$\therefore \quad \phi_{S_2} = -\phi_{S_1} = 20\mu\ \text{Wb}$

Question11

A charged particle is subjected to acceleration in a cyclotron as shown. The charged particle undergoes increase in its speed



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Options:

A. Only in the gap between D_1 and D_2

B. Only inside D_2

C. Inside D_1, D_2 and the gaps

D. Only inside D_1

Answer: C

Solution:

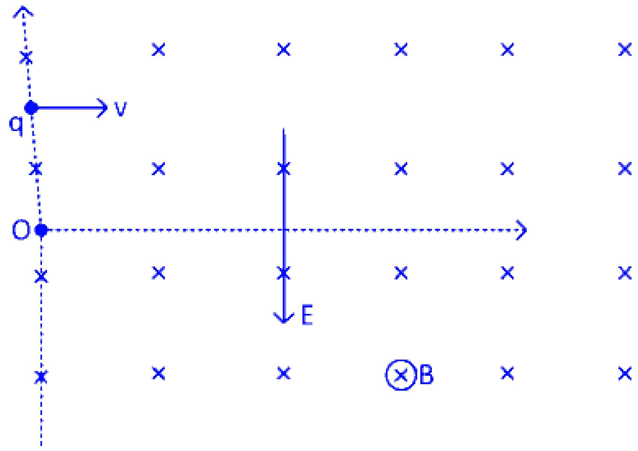
A charged particle experiences two different forces in a cyclotron as follows.

(i) Inside the Dees It is accelerated due to the magnetic field inside the dees.

(ii) In the Gaps It is accelerated due to the electric field.

Question12

A positively charged particle q of mass m is passed through a velocity selector. It moves horizontally rightward without deviation along the line $y = \frac{2mv}{qB}$ with a speed v. The electric field is vertically downwards and magnetic field is into the plane of paper. Now, the electric field is switched off at $t = 0$. The angular momentum of the charged particle about origin O at $t = \frac{\pi m}{qB}$ is



Options:

A. $\frac{4m^2E^2}{qB^3}$

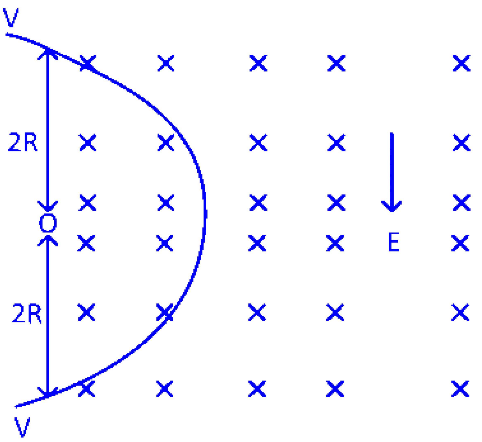
B. $\frac{2mE^2}{9B^3}$

C. Zero

D. $\frac{mE^3}{qB^2}$

Answer: A

Solution:



Radius of the circle, $r = \frac{mv}{Bq}$

$\therefore$ Equation of line, $y = \frac{2mv}{Bq} = 2R$

Time period, $T = \frac{2\pi m}{Bq}$

$t = \frac{\pi m}{Bq} = \frac{T}{2}$

$\therefore$ Angular momentum of charged particle about origin

$$L = mvy + mvy = 2mvy$$
$$= 2mv \times 2R$$
$$= 4mv \times \frac{mv}{Bq} = \frac{4m^2v^2}{Bq}$$

From velocity selector,

$$v = \frac{E}{B}$$
$$\therefore \quad L = \frac{4m^2E^2}{qB^3}$$

Question13

The torque acting on a magnetic dipole placed in uniform magnetic field is zero, when the angle between the dipole axis and the

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Options:

A. Zero

B. 45°

C. 60°

D. 90°

Answer: A

Solution:

Given, $\tau = 0$

$\Rightarrow MB\sin\theta = 0 \Rightarrow \sin\theta = 0$

$\Rightarrow \quad \theta = 0^\circ$

Question14

A proton and an alpha-particle moving with the same velocity enter a uniform magnetic field with their velocities perpendicular to the magnetic field. The ratio of radii of their circular paths is

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Options:

A. 2 : 1

B. 1 : 4

C. 4 : 1

D. 1 : 2

Answer: D

Solution:

Radius of charged particle moving on circular path in uniform magnetic field,

$$r=\frac{mv}{Bq}$$
$$r\propto\frac{m}{q}$$
$$\frac{r_p}{r_\alpha}=\frac{m_p}{m_\alpha}\cdot\frac{q_\alpha}{q_p}=\frac{m_p}{4m_p}\times\frac{2e}{e}=\frac{1}{2}$$
$$\Rightarrow r_p:r_\alpha=1:2$$

Question15

A metallic rod of mass per unit length $0.5\ \mathrm{kg\ m}^{-1}$ is lying horizontally on a smooth inclined plane which makes an angle of 30° with the horizontal. A magnetic field of strength $0.25\ \mathrm{T}$ is acting on it in the vertical direction. When a current I is flowing through it, the rod is not allowed to slide down. The quantity of current required to keep the rod stationary is

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Options:

A. 5.98 A

B. 14.76 A

C. 11.32 A

D. 7.14 A

Answer: C

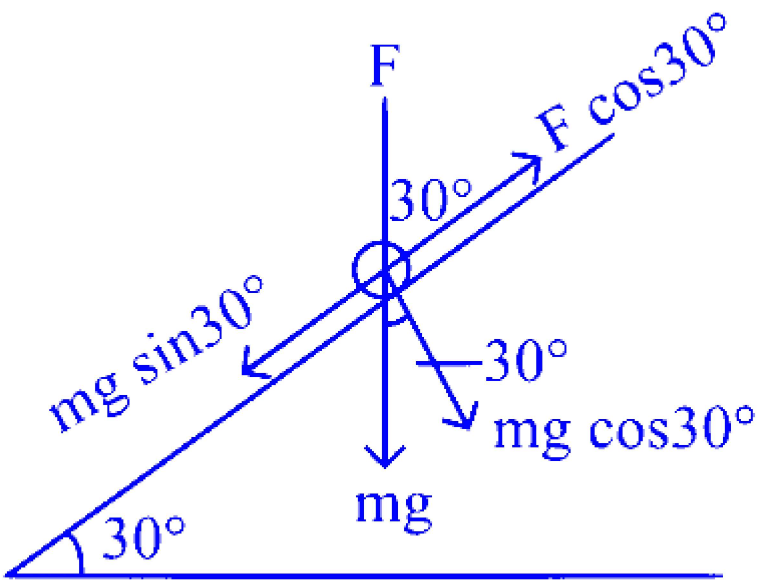
Solution:

Given, magnetic field, $B=0.25\ \mathrm{T}$

Mass per unit length, $\frac{m}{l}=0.5\ \mathrm{kg\ m}^{-1}$

$\theta=30^{\circ}$

The given situation is shown alongside.



At balance condition,

$F\cos 30^\circ = mg\sin 30^\circ$

$\Rightarrow \quad BIl\cos 30^\circ = mg\sin 30^\circ$

$\Rightarrow \quad BIl \times \frac{\sqrt{3}}{2} = mg\frac{1}{2} \Rightarrow \sqrt{3}BI = \left(\frac{m}{l}\right)g$

$I = \left(\frac{m}{l}\right)g \cdot \frac{1}{\sqrt{3}B} = 0.5 \times 10 \times \frac{1}{\sqrt{3} \times 0.25} = 11.32 \text{ A}$

Question16

A proton moves with a velocity of $5 \times 10^6 \hat{\mathbf{j}} m \hat{\ } \mathrm{m}^{-1}$ through the uniform electric field, $\overrightarrow{\mathbf{E}} = 4 \times 10^6 [2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.1\hat{\mathbf{k}}]\mathrm{Vm}^{-1}$ and the uniform magnetic field $\overrightarrow{\mathbf{B}} = 0.2[\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + \hat{\mathbf{k}}]\mathrm{T}$. The approximate net force acting on the proton is

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Options:

A. 25×10^{-13} N

B. 2.2×10^{-13} N

C. 20×10^{-13} N

D. 5×10^{-13} N

Answer: C

Solution:

Given, speed of proton, $v = 5 \times 10^6 \hat{\mathbf{j}} \mathrm{m/s}$

Electric field, $\mathrm{E} = 4 \times 10^6 [2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.\mathbf{k}\hat{\mathbf{k}}] \mathrm{V/m}$

Magnetic field, $\mathbf{B} = 0.2[\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + \hat{\mathbf{k}}] \mathrm{T}$

Charge on proton, $q = 1.6 \times 10^{-19} \mathrm{C}$

Net force acting on the proton is calculated according to Lorentz's force as

$$\begin{aligned}
&\mathbf{F} = q[\mathbf{E} + \mathbf{v} \times \mathbf{B}] \\
&= 1.6 \times 10^{-19} \left[4 \times 10^6 (2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.1\hat{\mathbf{k}})\right. \\
&\left.+5 \times 10^6 \hat{\mathbf{j}} \times 0.2(\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + \hat{\mathbf{k}})\right] \\
&= 1.6 \times 10^{-19} \times 10^6 [4(2\hat{\mathbf{i}} + 0.2\hat{\mathbf{j}} + 0.1\hat{\mathbf{k}}) \\
&+ (-\hat{\mathbf{k}} + 0 + 5\hat{\mathbf{i}})] \\
&\Rightarrow \mathbf{F} = 1.6 \times 10^{-13} [13\hat{\mathbf{i}} + 0.8\hat{\mathbf{j}} - 0.6\hat{\mathbf{k}}] \\
&\therefore \mathrm{F} = |\mathrm{F}| = 1.6 \times 10^{-13} \sqrt{(13)^2 + (0.8)^2 + (0.6)^2} \\
&= 1.6 \times 10^{-13} \sqrt{170} = 20.86 \times 10^{-13} \mathrm{~N} \\
&= 20 \times 10^{-13} \mathrm{~N}
\end{aligned}$$

Question17

A solenoid of length $50 \mathrm{~cm}$ having 100 turns carries a current of $2.5 \mathrm{~A}$. The magnetic field at one end of the solenoid is

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Options:

A. 6.28×10^{-4} T

B. 1.57×10^{-4} T

C. 9.42×10^{-4} T

D. 3.14×10^{-4} T

Answer: D

Solution:

Given, length of solenoid, $l = 50$ cm $= 0.5$ m

Number of turns, $N = 100$

Current, $I = 2.5$ A

Number of turns per unit length in the solenoid

$n = \frac{N}{l} = \frac{100}{0.5} = 200$ turns /m

Magnetic field at the one end of solenoid,

$$B = \frac{\mu_0 n I}{2} = \frac{4\pi \times 10^{-7} \times 200 \times 2.5}{2}$$
$$= 10\pi \times 10^{-5} = \pi \times 10^{-4} = 3.14 \times 10^{-4} \text{ T}$$

Question18

A circular coil of wire of radius r has n turns and carries a current I. The magnetic induction B at a point on the axis of the coil at a distance $\sqrt{3}r$ from its centre is

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Options:

A. $\frac{\mu_0 n I}{8r}$

B. $\frac{\mu_0 n I}{16r}$

C. $\frac{\mu_0 n I}{4r}$

D. $\frac{\mu_0 n I}{32r}$

Answer: B

Solution:

Magnetic field on the axis current carrying circular coil,

$B = \frac{\mu_0 I r^2 n}{2(x^2+r^2)^{3/2}}$

where, $I =$ current in the coil,

$n =$ number of turns,

$r =$ radius of coil.

and $x =$ distance of the point of observation from centre of coil.

Here, $x = \sqrt{3}r$

$$\therefore \quad B = \frac{\mu_0 I r^2 n}{2\left[(\sqrt{3}r)^2 + r^2\right]^{3/2}} = \frac{\mu_0 I r^2 n}{2[3r^2 + r^2]^{3/2}}$$
$$= \frac{\mu_0 I r^2 n}{2(4r^2)^{3/2}} = \frac{\mu_0 I r^2 n}{2[(2r)^2]^{3/2}} = \frac{\mu_0 I r^2 n}{2 \times 8r^3} = \frac{\mu_0 n I}{16r}$$

Question19

Which of the following statements proves that Earth has a magnetic field ?

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Options:

A. Earth is a planet rotating about the NorthSouth axis.

B. Earth is surrounded by ionosphere.

C. A large quantity of iron-ore is found in the Earth.

D. The intensity of cosmic rays stream of charged particles is more at the poles than at the equator.

Answer: D

Solution:

The intensity of cosmic rays stream of charged particles is move at the poles than at the equator because the Earth's magnetism is strongest at poles. Therefore, cosmic rays are deflected away from the equator. In order to reach at equator, they need to pass greater kinetic energy which shows that the Earth has a magnetic field.

Question20

A copper rod AB of length l is rotated about end A with a constant angular velocity ω. The electric field at a distance x from the axis of rotation is

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Options:

A. $\frac{m\omega^2 x}{e}$

B. $\frac{m\omega x}{e}$

C. $\frac{mx}{\omega^2 l}$

D. $\frac{me}{\omega^2 x}$

Answer: A

Solution:

In circular motion, net force on the particle is given as

$F_c = \frac{mv^2}{r} = m\omega^2 r$

where, ω is angular speed.When the rod rotates, electrons in it also rotates which produce electric field E at a distance x.

So, force on electron,

$F_e = eE$

This force provide the centripetal force,

$$\begin{aligned} \text{i.e.,} \quad F_c &= F_c \\ \text{or} \quad eE &= m\omega^2 x \\ \text{or} \quad E &= \frac{m\omega^2 x}{e} \end{aligned}$$

Question21

A strong magnetic field is applied on a stationary electron. Then, the electron

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Options:

A. moves in the direction of the field

B. moves in an opposite direction of the field

C. remains stationary

D. starts spinning

Answer: C

Solution:

When a magnetic field is applied to a charged particle, such as an electron, the force on the particle depends on its velocity relative to the field, and the direction of the force is given by the Lorentz force law. The magnetic component of the Lorentz force is described by the equation:

$\vec{F} = q\vec{v} \times \vec{B}$

where:

- $\vec{F}$ is the force on the particle,
- q is the electric charge of the particle,
- $\vec{v}$ is the velocity of the particle, and
- $\vec{B}$ is the magnetic field.

The symbol $\times$ denotes the cross product, which means that the force is always perpendicular to both the velocity of the charged particle and the direction of the magnetic field.

In the scenario described where the electron is initially stationary, its velocity is zero. Therefore, applying the equation:

$\vec{F} = q\vec{v} \times \vec{B} = q \cdot \vec{0} \times \vec{B} = \vec{0}$

Since both q and $\vec{B}$ are nonzero, but $\vec{v}$ is zero, the cross product yields a zero vector, which means there is no force on the stationary electron due to the magnetic field. Consequently, a stationary electron will not move just because a magnetic field is applied. It will remain stationary until an electric field or some other force acts upon it.

Therefore, the correct answer is:

Option C

remains stationary

Question22

Two parallel wires in free space are 10 cm apart and each carries a current of 10 A in the same direction. The force exerted by one wire on the other [per unit length] is

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Options:

A. $2 \times 10^{-4} \text{ Nm}^{-1}$ [attractive]

B. $2 \times 10^{-7} \text{ Nm}^{-1}$ [attractive]

C. $2 \times 10^{-4} \text{ Nm}^{-1}$ [repulsive]

D. $2 \times 10^{-7} \text{ Nm}^{-1}$ [repulsive]

Answer: A

Solution:

Given,

$r = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$
$I_1 = I_2 = 10 \text{ A}$

Force exerted by one wire on the other per unit length is given as

$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$

Substituting the given values, in the above relation, we get

$\frac{F}{l} = \frac{4\pi \times 10^{-7} \times 10 \times 10}{2\pi \times 10 \times 10^{-2}} = 2 \times 10^{-4} \text{ Nm}^{-1}$

Since, the current is flowing in the same direction, so the force will be attractive in nature.

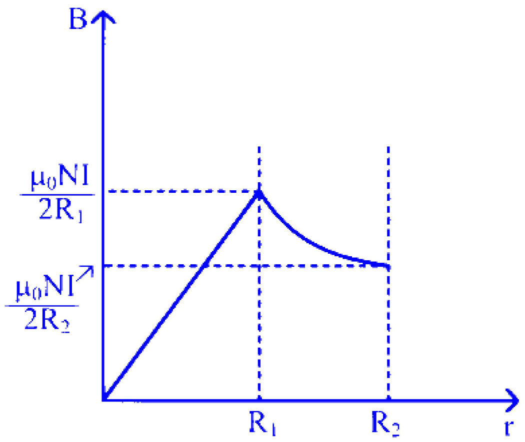
Question23

A toroid with thick windings of N turns has inner and outer radii R_1 and R_2, respectively. If it carries certain steady current I, the variation of the magnetic field due to the toroid with radial distance is correctly graphed in

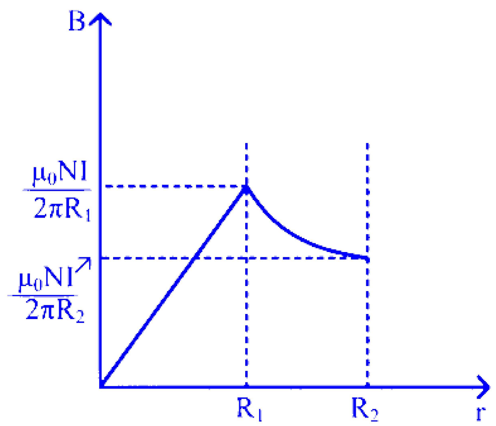
KCET 2021

Options:

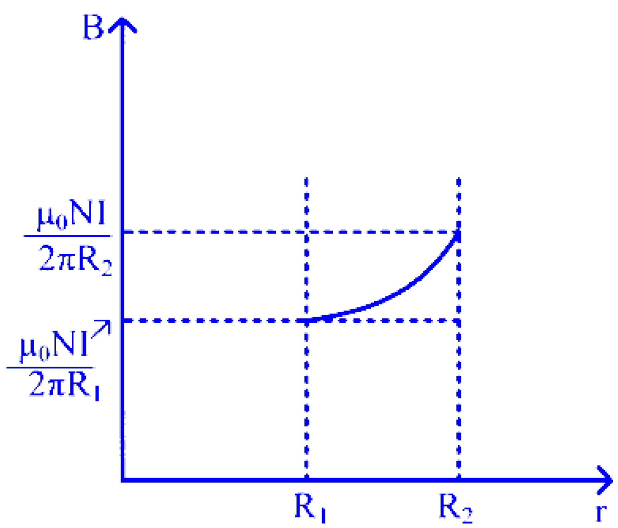
A.



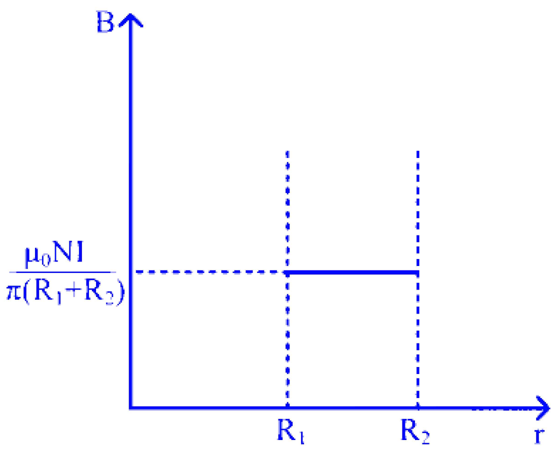
B.



C.



D.



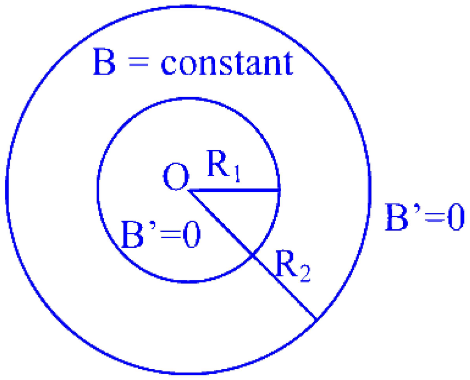
Answer: D

Solution:

Magnetic field due to toroid can be given as

(i) In the open space, exterior of a toroid,

$B = 0$



(ii) Inside the toroid,

$B = \frac{\mu_0 NI}{2\pi r}$

Here, $r = \frac{R_1+R_2}{2}$

$\Rightarrow \quad B = \frac{\mu_0 NI}{\pi(R_1+R_2)} = \text{ constant}$

So, the variations of B with r is correctly depicted in option (d).

Question24

A tightly wound long solenoid has n turns per unit length, a radius r and carries a current I. A particle having charge q and mass m is projected from a point on the axis in a direction perpendicular to the axis. The maximum speed of the particle for which the particle does not strike the solenoid is

KCET 2021

Options:

A. $\frac{\mu_0 n I q r}{m}$

B. $\frac{\mu_0 n I q r}{2m}$

C. $\frac{\mu_0 n I q r}{4m}$

D. $\frac{\mu_0 n I q r}{8m}$

Answer: B

Solution:

Magnetic force on the charged particle is given as

$F_B = q(v \times B) = qvB \sin\theta$

Here, $\theta = 90^\circ$

$F_B = qvB \sin 90^\circ = qvB$

Since, the particle is projected perpendicular to he field, so its trajectory will be circular in nature, where necessary centripetal force $= F_B$

$$\Rightarrow \quad \frac{mv^2}{r'} = qvB$$

$$\frac{mv^2}{\left(\frac{r}{2}\right)} = qvB \quad \left(\because r' = \frac{r}{2}\right)$$

$$\Rightarrow \quad v = \frac{qBr}{2m} \quad \text{.... (i)}$$

Magnetic field inside the solenoid is given as,

$B = \mu_0 n I$

Substituting the value of B in Eq. (i), we get

$v = \frac{\mu_0 n I q r}{2m}$

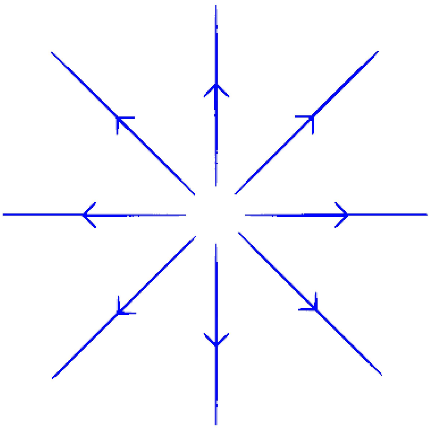
Question25

Which of the field pattern given below is valid for electric field as well as for magnetic field?

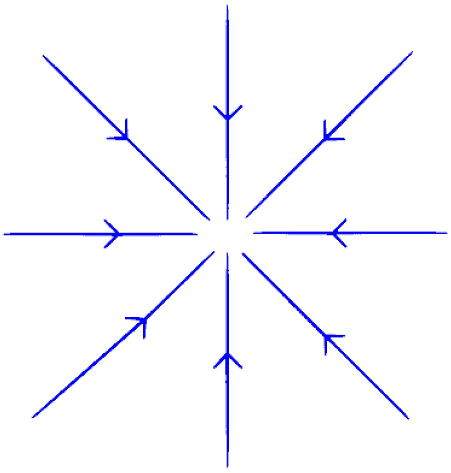
KCET 2021

Options:

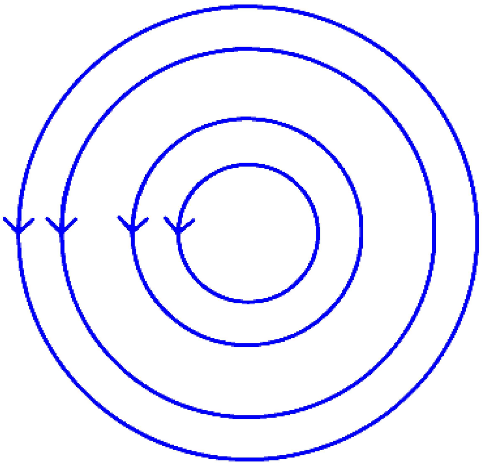
A.



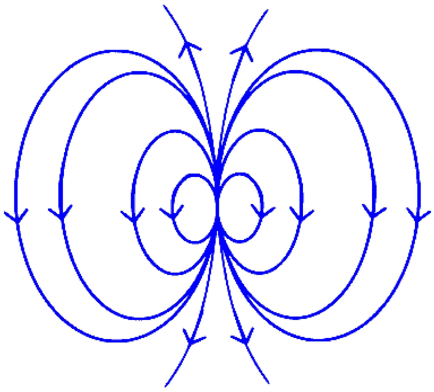
B.



C.



D.



Answer: D

Solution:

Option (a) and (b) represents electric field lines due to positive and negative charges. However, magnetic monopoles does not exist in nature.

So, option (a) and (b) is not correct for magnetic field lines.

Option (c) represents magnetic field lines for current carrying conductor.

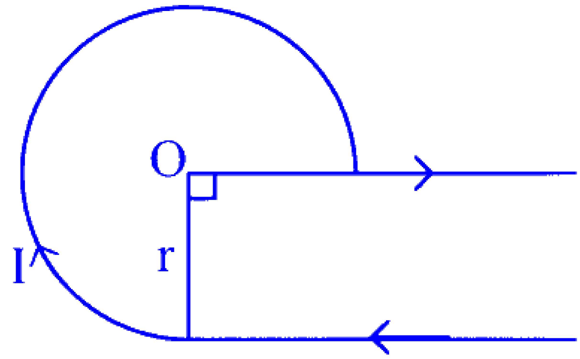
Also, electric field lines cannot form closed loop. So, option (c) is incorrect.

Option (d) is possible for magnetic field lines of solenoid and electric field lines of dipole.

Thus, option (d) is valid for both electric and magnetic field.

Question26

In the given figure, the magnetic field at O.



KCET 2020

Options:

A. $\frac{3}{4}\frac{\mu_0 I}{r}+\frac{\mu_0 I}{4\pi r}$

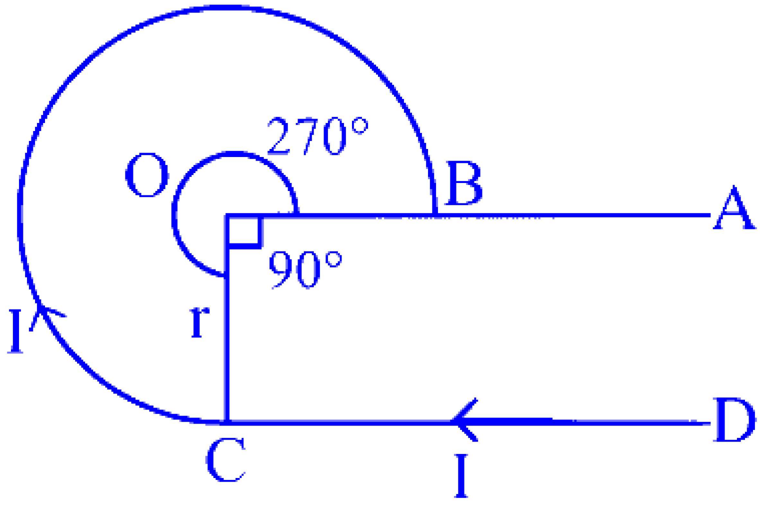
B. $\frac{3}{10}\frac{\mu_0 I}{r}-\frac{\mu_0 I}{4\pi r}$

C. $\frac{3}{8}\frac{\mu_0 I}{r}+\frac{\mu_0 I}{4\pi r}$

D. $\frac{3}{8}\frac{\mu_0 I}{r}-\frac{\mu_0 I}{4\pi r}$

Answer: C

Solution:



B_{net} = magnetic field due to straight wire AB+ magnetic field due to straight wire CD+ magnetic field due circular wire BC

Since, point O is along the length of the wire BA. So, $B_{AB} = 0$

$$\begin{aligned} B_{\text{net}} &= 0 + \frac{\mu_0}{4\pi} \cdot \frac{I}{r} + \frac{270}{360}\left(\frac{\mu_0 I}{2r}\right) \\ &= \frac{\mu_0 I}{4\pi r} + \frac{3}{4} \cdot \frac{\mu_0 I}{2r} \\ &= \frac{\mu_0 I}{4\pi r} + \frac{3\mu_0 I}{8r} \text{ (downward)} \end{aligned}$$

Question27

The magnetic field at the origin due to a current element $i d\mathbf{l}$ placed at a point with vector position $\mathbf{r}$ is

KCET 2020

Options:

A. $\frac{\mu_0 i}{4\pi} \frac{d\mathbf{l} \times \mathbf{r}}{r^3}$

B. $\frac{\mu_0 i}{4\pi} \frac{\mathbf{r} \times d\mathbf{l}}{r^3}$

C. $\frac{\mu_0 i}{4\pi} \frac{d\mathbf{l} \times \mathbf{r}}{r^2}$

D. $\frac{\mu_0 i}{4\pi} \frac{\mathbf{r} \times d\mathbf{l}}{r^2}$

Answer: A

Solution:

According to Biot-Savart's law, magnetic field at the origin due to a current element $id\mathbf{l}$ placed at a point with position vector $\mathbf{r}$ is given as.

$B = \frac{\mu_0 i}{4\pi} \cdot \frac{d\mathbf{l} \times \mathbf{r}}{r^3}$

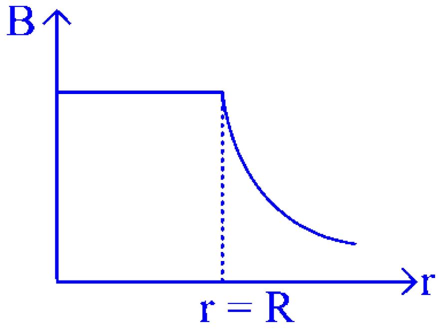
Question28

A long cylindrical wire of radius R carries a uniform current I flowing through it. The variation of magnetic field with distance r from the axis of the wire is shown by

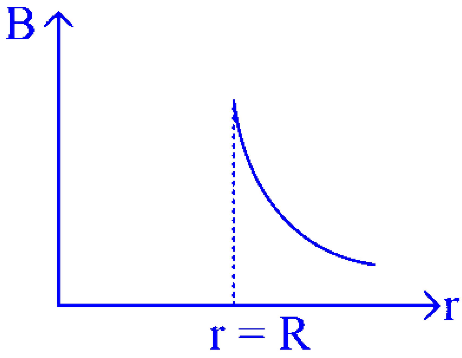
KCET 2020

Options:

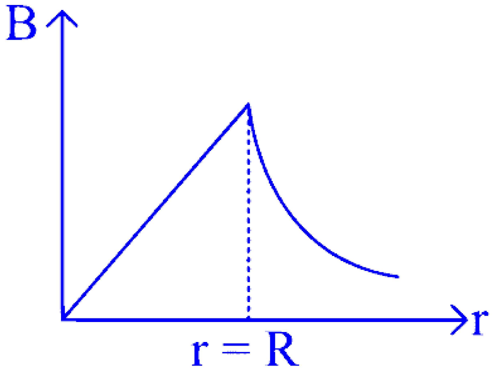
A.



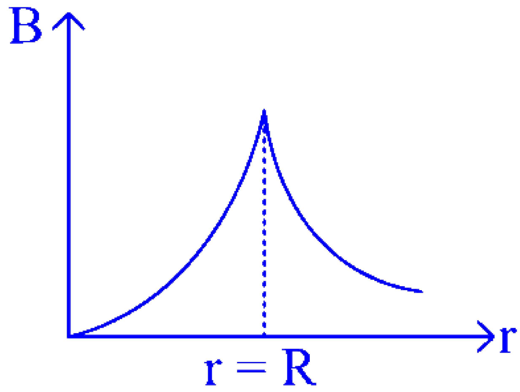
B.



C.



D.



Answer: C

Solution:

Magnetic field due to long cylindrical wire of radius R inside the cylinder at a distance $$r

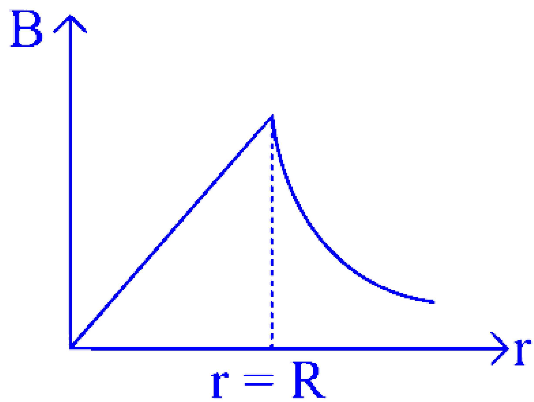
$$B_{\text{in}} = \frac{\mu_0}{2\pi} \cdot \frac{Ir}{R^2} \quad \text{[where, } I = \text{ current]}$$
$$\therefore \quad B_{\text{in}} \propto r \quad \ldots \text{(i)}$$

Magnetic field outside the current carrying cylindrical wire of radius R at a distance $r > R$ is given as

$B_{\text{out}} = \frac{\mu_0 I}{2\pi r}$

i.e. $B_{\text{out}} \propto \frac{1}{r}$ ... (ii)

From Eqs. (i) and (ii), graph between B and r drawn as



Question29

A cyclotron is used to accelerate protons $\left({}_1^l\text{H}\right)$ deuterons $\left({}_1^2\text{H}\right)$ and α -particles $\left({}_2^4\text{He}\right)$. While exiting under similar conditions, the

KCET 2020

Options:

A. α-particles

B. protons

C. deuterons

D. Same for all

Answer: C

Solution:

When a charged particle is accelerated by a potential difference V volts, then the radius of the trajectory of the path of the particle is given as,

$$r = \frac{\sqrt{2Km}}{Bq} = \frac{\sqrt{2qVm}}{Bq}$$

$$\Rightarrow \quad K = \frac{1}{2}\frac{B^2q^2r^2}{m} \text{ or } K \propto \frac{q^2}{m} \quad \text{.... (i)}$$

For protons $\left({}_1^1\text{H}\right)$, deuterons $\left({}_1^2\text{H}\right)$ and α-particles $\left({}_2^4\text{He}\right)$,

$$q_p : q_d : q_\alpha = 1 : 1 : 2 \quad \text{.... (ii)}$$
$$m_p : m_d : m_\alpha = 1 : 2 : 4 \quad \text{.... (iii)}$$

From Eqs. (i), (ii) and (iii), we can write

$$\Rightarrow \quad K_p : K_d : K_\alpha = 1 : \tfrac{1}{4} : 1$$

Thus, minimum kinetic energy is gained by deuterons.

Question30

The ratio of magnetic field at the centre of a current carrying circular coil to its magnetic moment is x, if the current and the radius both are doubled. The new ratio will become

KCET 2020

Options:

A. $2x$

B. $4x$

C. $\frac{x}{4}$

D. $\frac{x}{8}$

Answer: D

Solution:

Magnetic field at the centre of current carrying circular coil

$B=\frac{\mu_0 I}{2r}$

where, $I=$ current and $r=$ radius.

Magnetic dipole moment,

$$m=IA=I\cdot\pi r^2$$

$$\text{Given, }\frac{B}{m}=x$$

$$\Rightarrow\quad\frac{\frac{\mu_0 I}{2r}}{\pi I r^2}=x$$

$$\Rightarrow\quad\frac{\mu_0}{2\pi r^3}=x\quad\text{.... (i)}$$

When current and radius, both are doubled, then

$$\frac{B'}{m'}=\frac{\frac{\mu_0 2I}{2\cdot 2r}}{\pi(2I)(2r)^2}$$

$$=\frac{\frac{\mu_0 I}{2r}}{8\pi r^2 I}=\frac{\mu_0}{16\pi r^3}$$

$$=\frac{1}{8}\cdot\frac{\mu_0}{2\pi r^3}=\frac{x}{8}\quad\text{[from Eq. (i)]}$$

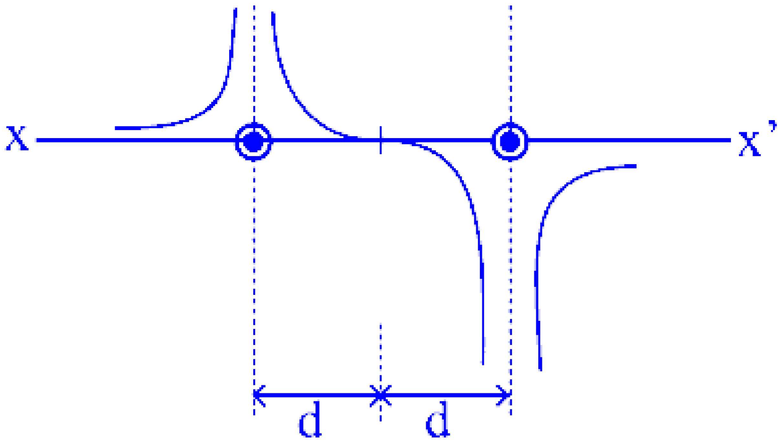
Question31

Two long straight parallel wires are a distance d part. They carry steady equal currents flowing out of the plane of the paper. The variation of magnetic field B along the line xx' is given by

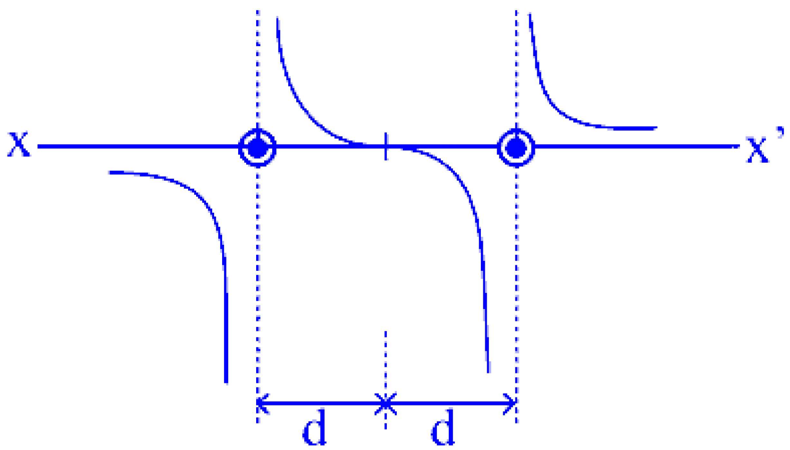
KCET 2020

Options:

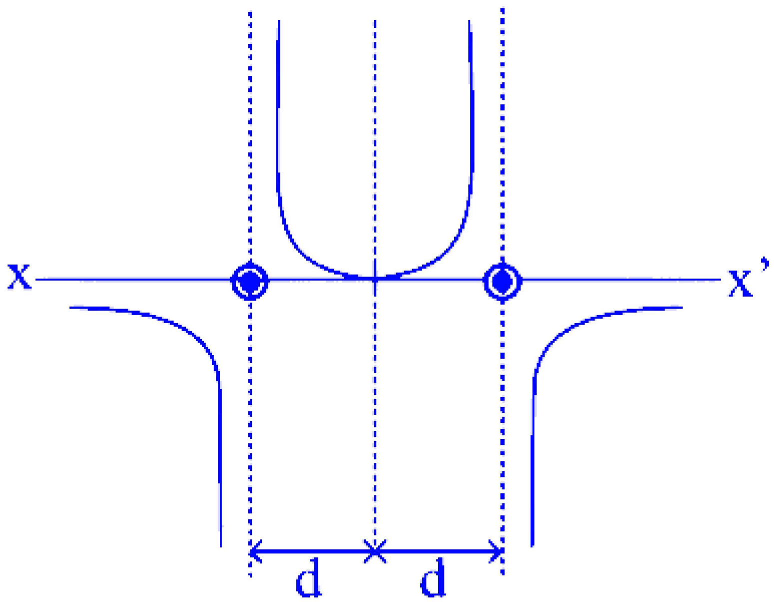
A.



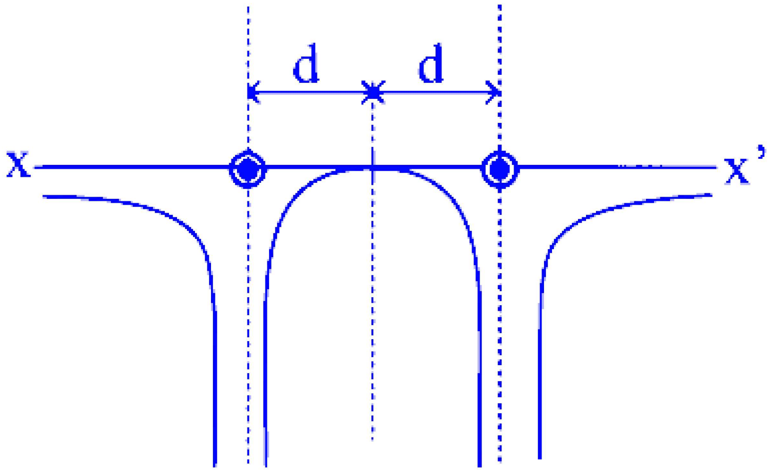
B.



C.



D.



Answer: B

Solution:

The magnetic field in between because of each will be in opposite direction.

$$\begin{aligned} B_{\text{in between}} &= \frac{\mu_0 i}{2\pi x}\hat{\mathbf{j}} - \frac{\mu_0 i}{2\pi(2d-x)} - \hat{\mathbf{j}} \\ &= \frac{\mu_0 i}{2\pi}\left[\frac{1}{x} - \frac{1}{2d-x}\right]\hat{\mathbf{j}} \end{aligned}$$

At $x = d, B_{\text{in between}} \quad = 0$

For $x < d, B_{\text{in between}} \quad = \hat{\mathbf{j}}$

For $x > d, B_{\text{in between}} \quad = -\hat{\mathbf{j}}$

Towards x, net magnetic field will add up and direction will be $(-j)$.

Towards x', net magnetic field will add up and direction will be $(\hat{\mathbf{j}})$.

Question32

A toroid has 500 turns per meter length. If it carries a current of 2A, the magnetic energy density inside the toroid is

KCET 2019

Options:

A. $0.628\ \text{J}/\text{m}^3$

B. $0.314 \mathrm{~J/m^3}$

C. $6.28 \mathrm{~J/m^3}$

D. $3.14 \mathrm{~J/m^3}$

Answer: A

Solution:

Given, Number of turns per unit length in toroid, $n=500$

Current, $I=2$ A,

Magnetic energy density inside the toroid,

$$
\begin{aligned}
U_B &= \frac{1}{2\mu_0} B_{\mathrm{rms}}^2 = \frac{1}{2\mu_0}(\mu_0 n I)^2 = \frac{\mu_0 n^2 I^2}{2} \\
&= \frac{4\pi \times 10^{-7} \times 500 \times 500 \times 2 \times 2}{2} \\
&= 0.628 \mathrm{~J/m^3}
\end{aligned}
$$

Question33

In a cyclotron a charged particle

KCET 2019

Options:

A. undergoes acceleration all the time

B. speeds up between the dees because of the magnetic field

C. speeds up in dee

D. slows down within a dee and speeds up between dees

Answer: A

Solution:

Only (a) $\rightarrow$ correct as between dees its accelerated due to both **E** and **B** and inside dees its accelerated due to **B** alone.

(c) incorrect $\rightarrow$ speed within. Dee is constant (electrostatic shielding)

(b) incorrect $\rightarrow$ between dees it speeds up due to electric field not magnetic field.

(d) incorrect $\rightarrow$ speed remains constant within dee.

Question34

The number of turns in a coil of galvanometer is tripled, then

KCET 2019

Options:

A. voltage sensitivity increases 3 times and current sensitivity remains constant

B. voltage sensitivity remains constant and current sensitivity increases 3 times

C. both voltage and current sensitivity remains constant

D. both voltage and current sensitivity decreases by 33%

Answer: B

Solution:

Current sensitivity, $I_s = \frac{NBA}{K}$

(where, $N =$ number of turns, $B =$ magnetic field strength, $A =$ area of coil, $K =$ figure of miret)

$\Rightarrow I_s \propto N$

$\Rightarrow$ Current sensitivity also increases 3 times Voltage sensitivity, $V_s = \frac{I_s}{R} = \left(\frac{NBA}{K}\right) \times \frac{1}{R}$

But $R \propto N$ (number of turns) and $I_s \propto N$

$\Rightarrow V_s$ remains constant

(as both I_s and R become N times)

Question35

Coersivity of a magnet where the ferromagnet gets completely demagnetized is $3 \times 10^3 \mathrm{~Am}^{-1}$. The minimum current required to be passes in a solenoid having 1000 turns per metre, so that the magnet gets completely demagnetized when placed inside the solenoid is

KCET 2019

Options:

A. 30 mA

B. 60 mA

C. 3 A

D. 6 A

Answer: C

Solution:

Coersivity, (reverse field intensity to reduce field to zero) $\mathrm{H} = 3 \times 10^3 \mathrm{Am}^{-1}$.

number of turns/meter, $n = 1000 \mathrm{~m}^{-1}$

We know, $B = \mu_0 H$ .... (i)

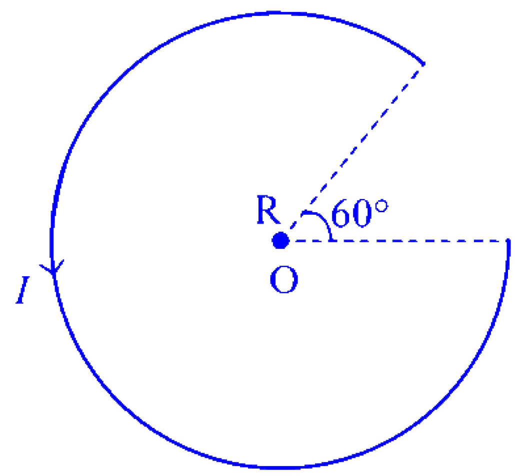
also field due to solenoid, $B = \mu_0 n I$ .... (ii)

From Eqs (i) and (ii)

$\mu_0 n I = \mu_0 H \Rightarrow I = \frac{H}{n} = \frac{3 \times 10^3}{10^3} = 3 \mathrm{~A}$

Question36

The magnetic fields at the centre O in the given figure is



KCET 2019

Options:

A. $\frac{7}{14} \frac{\mu_0 I}{R}$

B. $\frac{5}{12} \frac{\mu_0 I}{R}$

C. $\frac{3}{10} \frac{\mu_0 I}{R}$

D. $\frac{\mu_0 I}{12R}$

Answer: B

Solution:

Here, the length of the wire $= \left(\frac{\theta}{2\pi}\right) \times 2\pi R$

$\therefore$ magnetic field due to this wire

$$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right); B = \frac{\mu_0 I}{2R}\left(\frac{5\pi}{3}\right) \times \frac{1}{2\pi}$$

$$\left[\theta = \frac{6\pi}{3} - \frac{\pi}{3} (\because \theta = 360^\circ - 60^\circ) \Rightarrow 300^\circ = \frac{5\pi}{3}\right]$$

$$B = \frac{5\mu_0 I}{12R}$$

Question37

The correct Biot-Savart law in vector form is

KCET 2018

Options:

A. $d\mathbf{B}=\frac{\mu_0}{4\pi}\cdot\frac{l(d\times\mathbf{r})}{r^2}$

B. $d\mathbf{B}=\frac{\mu_0}{4\pi}\cdot\frac{|(d\ \times\mathbf{r})}{r^3}$

C. $d\mathbf{B}=\frac{\mu_0}{4\pi}\cdot\frac{|d|}{r^2}$

D. $d\mathbf{B}=\frac{\mu_0}{4\pi}\cdot\frac{|d|}{r^3}$

Answer: B

Solution:

Let's break down the reasoning:

The Biot-Savart law for a current element is typically given by

$d\mathbf{B}=\frac{\mu_0}{4\pi}\frac{I\,d\mathbf{l}\times\mathbf{r}}{r^3}$,

where:

I is the current,

$d\mathbf{l}$ is the differential length vector (in the direction of the current),

$\mathbf{r}$ is the vector pointing from the current element to the field point, and

$r=|\mathbf{r}|$.

Alternatively, one might see it expressed with the unit vector $\hat{\mathbf{r}}=\mathbf{r}/r$ as

$d\mathbf{B}=\frac{\mu_0}{4\pi}\frac{I\,d\mathbf{l}\times\hat{\mathbf{r}}}{r^2}$.

Notice that since replacing $\hat{\mathbf{r}}$ with $\mathbf{r}/r$ in the numerator gives

$d\mathbf{l}\times\hat{\mathbf{r}}=\frac{d\mathbf{l}\times\mathbf{r}}{r}$,

the formula becomes

$d\mathbf{B}=\frac{\mu_0}{4\pi}\frac{I\,d\mathbf{l}\times\mathbf{r}}{r^3}$.

Comparing with the options provided:

Option A uses r^2 in the denominator along with what appears to be a cross product notation but does not match the standard vector form when the full displacement vector is used.

Option B correctly shows a cross product in the numerator with r^3 in the denominator, which is equivalent to the standard form.

Options C and D only involve the magnitude of the differential element (indicated by the absolute value) and omit the crucial vector (cross product) quality of the law.

Thus, the correct Biot-Savart law in vector form is given by Option B:

$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{I\, d\mathbf{l} \times \mathbf{r}}{r^3}.$

Therefore, the correct answer is Option B.

Question38

An electron is moving in a circle of radius r in a uniform magnetic field B. Suddenly, the field is reduced to $\frac{B}{2}$. The radius of the circular path now becomes

KCET 2018

Options:

A. $\frac{r}{2}$

B. $2r$

C. $\frac{r}{4}$

D. $4r$

Answer: B

Solution:

An electron is moving in a circular path with radius r in a uniform magnetic field B. If the magnetic field is suddenly reduced to $\frac{B}{2}$, we need to determine the new radius of the circular path.

Initially, given the magnetic field $B_1 = B$, the velocity v of the electron is related to the radius r by the equation:

$v = \frac{qB_1 r}{m}$

From this, we can express the initial radius r_1 as:

$r_1 = \frac{mv}{qB_1}$

When the magnetic field is reduced to half its initial value, the new magnetic field B_2 becomes:

$B_2 = \frac{B_1}{2}$

The new radius r_2, for the reduced field B_2, can be calculated using the same relationship:

$r_2 = \frac{mv}{qB_2}$

Substituting B_2 in the equation, we find:

$r_2 = \frac{mv}{q\left(\frac{B_1}{2}\right)} = \frac{2mv}{qB_1}$

Since $r_1 = \frac{mv}{qB_1}$, it follows that:

$r_2 = 2r_1$

Thus, when the magnetic field is halved, the radius of the path doubles.

Question39

A charge q is accelerated through a potential difference V. It is then passed normally through a uniform magnetic field, where it moves in a circle of radius r. The potential difference required to move it in a circle of radius $2r$ is

KCET 2018

Options:

A. $2V$

B. 4 V

C. 1 V

D. $3V$

Answer: B

Solution:

Let's analyze the problem step by step.

When a charge q is accelerated through a potential difference V, it gains kinetic energy given by

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

Solving for the speed v, we have:

$$v = \sqrt{\frac{2qV}{m}}$$

When this charge enters a uniform magnetic field B perpendicularly, the magnetic force provides the centripetal force required for circular motion:

$$qvB = \frac{mv^2}{r}$$

Rearranging for r, we find:

$$r = \frac{mv}{qB}$$

Substitute the expression for v into the radius equation:

$$r = \frac{m}{qB}\sqrt{\frac{2qV}{m}} = \frac{\sqrt{2mV}}{B\sqrt{q}}$$

Let the new potential difference be V' that would result in a circular path of radius $2r$. Following the same derivation:

$$2r = \frac{\sqrt{2mV'}}{B\sqrt{q}}$$

Now, divide the equation for the new radius by the equation for the original radius:

$$\frac{2r}{r} = \frac{\sqrt{2mV'}}{\sqrt{2mV}}$$

This simplifies to:

$$2 = \sqrt{\frac{V'}{V}}$$

Squaring both sides gives:

$$4 = \frac{V'}{V} \implies V' = 4V$$

Thus, the potential difference required to move the charge in a circle of radius $2r$ is $4V$.

The correct answer is Option B: $4V$.

Question40

A cyclotron's oscillator frequency is 10 MHz and the operating magnetic field is 0.66 T . If the radius of its dees is 60 cm , then the kinetic energy of the proton beam produced by the accelerator is

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Options:

A. 9 MeV

B. 10 MeV

C. 7 MeV

D. 11 MeV

Answer: C

Solution:

Let's determine the kinetic energy step by step.

The maximum speed a proton reaches in a cyclotron (when it has just reached the outer edge of the dee with radius r) is given by:

$v = \frac{qBr}{m}$

where

$q = 1.60 \times 10^{-19}$ C (charge of a proton),

$B = 0.66$ T (magnetic field),

$r = 0.60$ m (dee radius),

$m = 1.67 \times 10^{-27}$ kg (mass of a proton).

The kinetic energy (non-relativistic) is:

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

Substituting the expression for v:

$K = \frac{1}{2}m\left(\frac{qBr}{m}\right)^2 = \frac{q^2B^2r^2}{2m}$

Plug in the numbers:

Calculate q^2:

$q^2 = (1.60 \times 10^{-19})^2 = 2.56 \times 10^{-38}\ \mathrm{C}^2$

Calculate B^2:

$B^2 = (0.66)^2 \approx 0.4356\ \mathrm{T}^2$

Calculate r^2:

$r^2 = (0.60)^2 = 0.36\ \mathrm{m}^2$

Now, substitute into the kinetic energy formula:

$K = \frac{2.56 \times 10^{-38} \times 0.4356 \times 0.36}{2 \times 1.67 \times 10^{-27}}$

First, compute the numerator:

Multiply the numbers:

$0.4356 \times 0.36 \approx 0.1568$

$2.56 \times 10^{-38} \times 0.1568 \approx 4.01 \times 10^{-39}$

Then, compute the denominator:

$2 \times 1.67 \times 10^{-27} = 3.34 \times 10^{-27}$

So,

$K \approx \frac{4.01 \times 10^{-39}}{3.34 \times 10^{-27}} \approx 1.20 \times 10^{-12}\ \text{J}$

Convert the kinetic energy from joules to electron volts (eV). Recall that:

$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$

Therefore,

$K \approx \frac{1.20 \times 10^{-12}\ \text{J}}{1.60 \times 10^{-19}\ \text{J/eV}} \approx 7.5 \times 10^{6}\ \text{eV} = 7.5\ \text{MeV}$

Comparing with the options provided, the closest answer is:

Option C: 7 MeV

Thus, the kinetic energy of the proton beam produced by the cyclotron is approximately 7 MeV.

Question41

A proton, a deuteron and an α-particle are projected perpendicular to the direction of a uniform magnetic field with same kinetic energy. The ratio of the radii of the circular paths described by them is

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Options:

A. $1 : \sqrt{2} : 1$

B. $1 : \sqrt{2} : \sqrt{2}$

C. $\sqrt{2} : \sqrt{2} : 1$

D. $\sqrt{2} : 1 : 1$

Answer: A

Solution:

To solve this problem, we need to determine the ratio of the radii of the circular paths described by a proton, a deuteron, and an alpha particle when projected perpendicular to a uniform magnetic field with the same kinetic energy.

Let's start with the relationship for the radius of circular motion in a magnetic field:

$r = \frac{mv}{qB}$

Given that the kinetic energy (K.E) is the same for each particle, we can use the relationship for kinetic energy:

$\mathrm{K.E} = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{\frac{2\times\mathrm{K.E}}{m}}$

Substituting this into the radius formula gives us:

$r = \frac{\sqrt{2m\times\mathrm{K.E}}}{qB}$

Since the kinetic energy is the same for all particles, $r \propto \frac{\sqrt{m}}{q}$. Thus, comparing their radii, we have:

For a proton (p): $r_p \propto \sqrt{\frac{m_p}{q_p}}$

For a deuteron (d): $r_d \propto \sqrt{\frac{2m_p}{q_p}}$

For an alpha particle (α): $r_\alpha \propto \sqrt{\frac{4m_p}{2q_p}} = \sqrt{\frac{2m_p}{q_p}}$

Therefore, the ratio of their radii is:

$r_p : r_d : r_\alpha = 1 : \sqrt{2} : 1$

Thus, the correct answer for the ratio of the radii is $1 : \sqrt{2} : 1$.

Question42

A magnetic dipole of magnetic moment 6×10^{-2} A-m ^{2} and moment of inertia $12 \times 10^{-6}\ \mathrm{kg} - \mathrm{m}^2$ performs oscillations in a magnetic field of 2×10^{-2} T. The time taken by the dipole to complete 20 oscillations is ($\pi \approx 3$)

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Options:

A. 18 s

B. 6 s

C. 36 s

D. 12 s

Answer: D

Solution:

Given:

Magnetic moment, $M = 6 \times 10^{-2}$ A-m^2

Moment of inertia, $I = 12 \times 10^{-6}$ kg-m^2

Magnetic field, $B = 2 \times 10^{-2}$ T

To find the time period for oscillations, we use the formula:

$t = 2\pi\sqrt{\frac{I}{MB}}$

Calculating:

$t = 2\pi\sqrt{\frac{12\times10^{-6}}{6\times10^{-2}\times2\times10^{-2}}}$

$= 2\pi\sqrt{\frac{1.2\times10^{-5}}{12\times10^{-4}}}$

$= 2\pi \times 0.1 = 0.2\pi$

For 20 oscillations, the total time taken is:

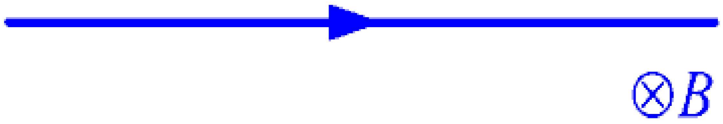
Time (T) $= 20 \times 0.2\pi$

$= 4\pi \approx 12$ s

Thus, the time taken for the dipole to complete 20 oscillations is approximately 12 seconds.

Question43

A straight wire of length 50 cm carrying a current of 2.5 A is suspended in mid-air by a uniform magnetic field of 0.5 T (as shown in figure). The mass of the wire is ($g = 10\ \mathrm{ms}^{-2}$)



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Options:

A. 250 gm

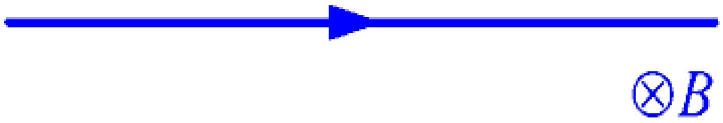
B. 125 gm

C. 62.5 gm

D. 100 gm

Answer: C

Solution:



Given, length of wire $(l) = 50 \text{ cm} = 50 \times 10^{-2}$ m current $(I) = 2.5$ A

magnetic field $(B) = 0.5$ T

$g = 10 \text{ ms}^{-2}$

For the balance condition,

$$F_B = mg$$
$$BIl = mg$$
$$m = \frac{BIl}{g}$$
$$= \frac{0.5 \times 2.5 \times 50 \times 10^{-2}}{10} = 62.5 \text{ g}$$

Question44

The magnetic field at the centre of a current carrying loop of radius 0.1 m is $5\sqrt{5}$ times that at a point along its axis. The distance of this point from the centre of the loop is

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Options:

A. 0.1 m

B. 0.2 m

C. 0.05 m

D. 0.25 m

Answer: B

Solution:

To find the distance of a point along the axis of a current-carrying loop where the magnetic field is $5\sqrt{5}$ times weaker than at the center, we can use the ratio of the magnetic field at the center of the loop to the field at a point on its axis:

$$\frac{B_{\text{centre}}}{B_{\text{axis}}} = \left(1 + \frac{x^2}{r^2}\right)^{3/2}$$

Given that:

$$B_{\text{centre}} = 5\sqrt{5} \cdot B_{\text{axis}}$$

Substitute this into the equation:

$$5\sqrt{5} = \left(1 + \frac{x^2}{(0.1)^2}\right)^{3/2}$$

Next, square both sides of the equation to eliminate the power of $\frac{3}{2}$:

$$(5\sqrt{5})^2 = \left(1 + \frac{x^2}{(0.1)^2}\right)^3$$

This simplifies to:

$$125 = \left(1 + \frac{x^2}{0.01}\right)^3$$

Taking the cube root of both sides gives us:

$$\sqrt[3]{125} = 1 + \frac{x^2}{0.01}$$

Solving for x^2, we have:

$5 = 1 + \frac{x^2}{0.01}$

Subtract 1 from both sides:

$4 = \frac{x^2}{0.01}$

Thus,

$x^2 = 4 \times 0.01 = 0.04$

Finally, solve for x:

$x = \sqrt{0.04} = 0.2\,\mathrm{m}$

Therefore, the distance from the center of the loop to the point along its axis is $0.2\,\mathrm{m}$.
