Moving Charges and Magnetism

Question1

A wire of length ' L ' carries a current ' I '. If the wire is turned into a square coil of single turn, the maximum magnitude of the torque in a given magnetic field $(\vec{B})$ is

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Options:

A.

$\frac{IBL}{16}$

B.

$\frac{IBL}{8}$

C.

$\frac{IBL^2}{8}$

D.

$\frac{IBL^2}{16}$

Answer: D

Solution:

Step 1: Side length of the square

If the wire of total length L is made into a square loop (1 turn), the perimeter is L.

Side of square $= \frac{L}{4}$.

Step 2: Area of the square loop

$A = \left(\frac{L}{4}\right)^2 = \frac{L^2}{16}.$

Step 3: Torque on a current loop in a magnetic field

The magnetic torque on a current loop is given by:

$\tau = \mu B \sin\theta$

where $\mu = I \times A$ is the magnetic dipole moment, and maximum torque occurs when $\sin\theta = 1$.

$\tau_{\text{max}} = IAB.$

Step 4: Substitution

$\tau_{\text{max}} = I \cdot \frac{L^2}{16} \cdot B.$

$\tau_{\text{max}} = \frac{IBL^2}{16}.$

✅ **Final Answer:**

$\boxed{\frac{IBL^2}{16}}$

Correct option: D

Question2

A circular coil carrying current has radius ' R '. The distance from the centre of the coil on the axis where the magnetic induction will be $\frac{1}{27}$ th of its value at the centre of the coil is

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Options:

A.

$3\sqrt{2}R$

B.

$3R$

C.

$2\sqrt{2}$R

D.

$2R$

Answer: C

Solution:

Step 1: Formula for magnetic field on axis

Magnetic field at a point on the axis of a current-carrying circular coil at distance x from the center is:

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

At the **center** ($x = 0$):

$B(0) = \frac{\mu_0 I}{2R}$

Step 2: Ratio condition

We want:

$B(x) = \frac{1}{27} B(0)$

Substitute:

$\frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}} = \frac{1}{27} \cdot \frac{\mu_0 I}{2R}$

Cancel $\frac{\mu_0 I}{2}$:

$\frac{R^2}{(R^2+x^2)^{3/2}} = \frac{1}{27R}$

Step 3: Simplify equation

$\frac{R^2}{(R^2+x^2)^{3/2}} = \frac{1}{27R}$

Cross multiply:

$27R^3 = (R^2 + x^2)^{3/2}$

Step 4: Square both sides

$(27R^3)^2 = (R^2 + x^2)^3$

$729R^6 = (R^2 + x^2)^3$

Take cube root:

$9R^2 = R^2 + x^2$

So:

$x^2 = 8R^2$

$x = 2\sqrt{2}R$

✅ **Final Answer:**

$\boxed{2\sqrt{2}R}$

Correct option: C

Question3

Lorentz magnetic force is acting on a particle of charge q moving with velocity $\vec{V}$ in a magnetic field $\vec{B}$. The work done by this force on the charged particle is

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Options:

A.

zero

B.

one

C.

infinity

D.

qB $\sin\theta$

Answer: A

Solution:

The Lorentz force due to a magnetic field only is:

$\vec{F} = q\vec{V} \times \vec{B}$.

Now, the work done by a force in moving a particle is:

$\frac{dW}{dt} = \vec{F} \cdot \vec{V}$.

Substitute:

$\vec{F} \cdot \vec{V} = (q\vec{V} \times \vec{B}) \cdot \vec{V}$.

But $\vec{V} \times \vec{B}$ is perpendicular to $\vec{V}$, so the dot product is zero.

Hence,

$\frac{dW}{dt} = 0 \quad \Longrightarrow \quad W = 0$.

✅ **Correct Answer: Option A (zero).**

Question4

Two wires of equal lengths are bent in the form of a square and a circular loop. They are suspended in a uniform magnetic field and same current is passed through them. Torque experienced by

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Options:

A.

square loop is greater.

B.

both the loops is same but not zero.

C.

both the loops is zero.

D.

circular loop is maximum.

Answer: D

Solution:

The formula for torque is:

$\tau = IAB\sin\theta$where τ is torque, I is current, A is the area of the loop, B is the magnetic field, and θ is the angle between the field and the normal to the loop.

Since the current, magnetic field, and angle are the same for both shapes, the torque mainly depends on the area A of each loop.

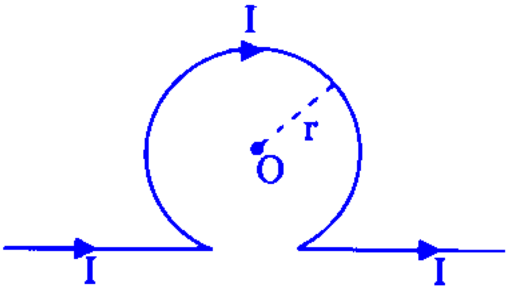
For a given length of wire (same perimeter), a circle always has a bigger area than a square.

So, the circular loop will experience a greater torque than the square loop.

Question5

An infinitely long straight conductor carrying current ' I ' is bent into a shape as shown in figure. The radius of the circular loop is ' r '. The magnetic induction at the centre of the loop at point ' O ' is

(μ_0 = permeability of free space)



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Options:

A. zero

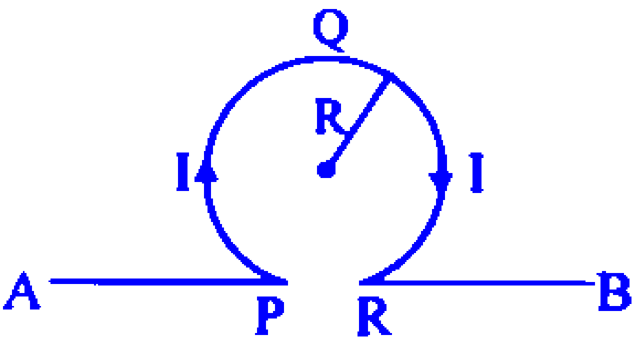
B. $\frac{\mu_0 \mathrm{I}}{4\pi \mathrm{r}}(\pi - 1)$

C. $\frac{\mu_0 \mathrm{I}}{2\pi \mathrm{r}}(\pi + 1)$

D. $\frac{\mu_0 \mathrm{I}}{2\pi \mathrm{r}}(\pi - 1)$

Answer: D

Solution:



Magnetic field at centre O = magnetic field due to section AB+ magnetic field due to section PQR

$B_O = B_{AB} + B_{PQR}$

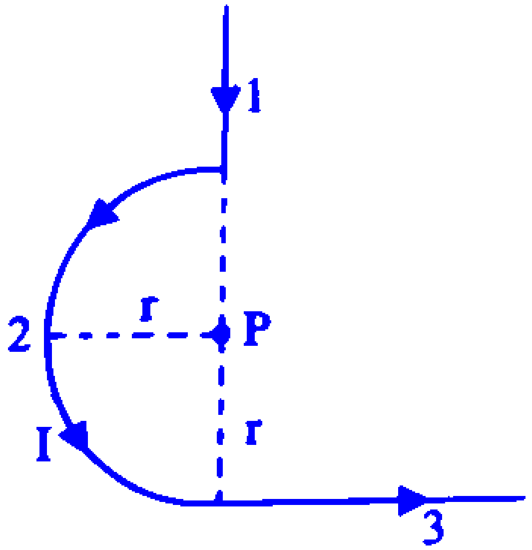
$B_{AB} = \frac{\mu_0 I}{2\pi R}$ ...(outside the plane of paper)

and $B_{PQR} = \frac{\mu_0 I}{2R}$ ....(inside the plane of paper)

$\therefore \quad B_O = \frac{\mu_0 I}{2R} - \frac{\mu_0 I}{2\pi R} = \frac{\mu_0 I(\pi-1)}{2\pi R}$

Question6

In the following figure magnitude of the magnetic field at the point p is



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Options:

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

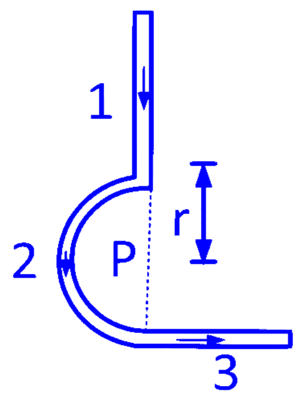
B. $\frac{\mu_0 I}{4\pi r}+\frac{\mu_0 I}{2r}$

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

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

Answer: C

Solution:



Magnetic fields due to different portions 1, 2 and 3 are respectively,

$\mathrm{B}_1=0,$

$\mathrm{B}_2=\frac{\mu_0}{4\pi}\cdot\frac{\pi \mathrm{I}}{\mathrm{r}}$ (directed outside the paper)

$\mathrm{B}_3=\frac{\mu_0}{4\pi}\cdot\frac{\mathrm{I}}{\mathrm{r}}$ (directed outside the paper)

$\therefore \quad B_{net}=B_2+B_3=\frac{\mu_0 I}{4\pi r}+\frac{\mu_0 I}{4r}$

Question7

A circular coil carrying current ' T ' has a radius ' r ' and ' n ' turns. The magnetic field along the axis of a coil at a distance ' $2\sqrt{2}r$ ', from its centre is ($\mu_0=$ permeability of free space, n is very small)

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Options:

A. $\frac{\mu_0 \mathrm{nI}}{9\mathrm{r}}$

B. $\frac{\mu_0 n I}{18 r}$

C. $\frac{\mu_0 \mathrm{nI}}{54\mathrm{r}}$

D. $\frac{\mu_0 \mathrm{nI}}{27\mathrm{r}}$

Answer: C

Solution:

Magnetic field at a point on the axis,

$$\mathrm{B}=\frac{\mu_0}{4 \pi} \times \frac{2 \pi \mathrm{nIR}^2}{\left(\mathrm{R}^2+\mathrm{x}^2\right)^{3 / 2}}$$

$$=\frac{\mu_0}{4 \pi} \times \frac{2 \pi n r^2}{\left[r^2+(2 \sqrt{2} r)^2\right]^{3 / 2}}$$

$$=\frac{\mu_0}{4 \pi} \times \frac{2 \pi n r^2}{\left[r^2+8 r^2\right]^{3 / 2}}=\frac{\mu_0}{4 \pi} \times \frac{2 \pi n r^2}{\left(9 r^2\right)^{3 / 2}}=\frac{\mu_0 n I}{54 r}$$

Question8

The magnetic field intensity H at the centre of a long solenoid having n turns per unit length and carrying a current I, when no material is kept in it is ($\mu_0=$ permeability of free space)

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Options:

A. $\mu_0 \mathrm{nI}$

B. $\frac{\mathrm{n}}{\mathrm{I}}$

C. nI

D. $\frac{\mu_0}{\mathrm{nI}}$

Answer: C

Solution:

Step 1: Recall the relation

Magnetic field intensity H (measured in A/m) is given by

$H = \frac{NI}{l}$

where N is number of turns, l is length of solenoid, and I is current.

For n turns per unit length,

$\frac{N}{l} = n \quad \Longrightarrow \quad H = nI.$

Step 2: Magnetic flux density B

The magnetic induction inside solenoid is

$B = \mu_0 H = \mu_0 nI.$

But the question specifically asks for **magnetic field intensity** H (not B).

Final Answer:

$H = nI$

Correct Option = C. ✅

Question9

Current I is carried in a wire of length ' L '. If wire is bent into a circular coil of single turn, the maximum torque in a given magnetic field B is

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Options:

A. $\frac{\mathrm{L}^2 \mathrm{~B}}{4\pi}$

B. $\frac{\mathrm{L}^2 \mathrm{IB}}{4\pi}$

C. $\frac{L^2 B^2}{2}$

D. $\frac{L^2 IB}{2}$

Answer: B

Solution:

Step 1: Relation for torque

The maximum torque on a current-carrying coil in a magnetic field is:

$\tau_{\max} = n I A B$

where:

- n = number of turns,
- I = current,
- A = area of coil,
- B = magnetic field strength.

Here, number of turns $n = 1$.

Step 2: Find radius of the coil

The wire has length L. It is bent into a circle.

$L = 2\pi r \quad \Rightarrow \quad r = \frac{L}{2\pi}$

Step 3: Area of coil

$A = \pi r^2 = \pi\left(\frac{L}{2\pi}\right)^2 = \frac{L^2}{4\pi}$

Step 4: Torque

$\tau_{\max} = I \cdot A \cdot B = I \cdot \frac{L^2}{4\pi} \cdot B$

$\tau_{\max} = \frac{L^2 IB}{4\pi}$

✅ Final Answer:

Option B: $\frac{L^2 IB}{4\pi}$

Question10

A square of side ' L ' metre lies in $x-y$ plane in a region where the magnetic field is $\overline{\mathrm{B}}$ and $\vec{B}=B_0(2\hat{i}+3\hat{j}+4\hat{k})$, where B_0 is constant. The magnitude of flux passing through the square (in weber) is

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Options:

A. $\sqrt{29}\,\mathrm{B}_0\,\mathrm{L}^2$

B. $4\,\mathrm{B}_0\,\mathrm{L}^2$

C. $2\,\mathrm{B}_0\,\mathrm{L}^2$

D. $3\,\mathrm{B}_0\,\mathrm{L}^2$

Answer: B

Solution:

$$\text{Magnetic flux } (\phi)=\vec{B}\cdot\vec{A}$$
$$\text{Here, } \vec{B}=B_0(2\hat{i}+3\hat{j}+4\hat{k})$$
$$\vec{A}=L^2\hat{k}$$
$$\therefore\quad \phi=\left(B_0(2\hat{i}+3\hat{j}+4\hat{k})\right)\cdot\left(L^2\hat{k}\right)$$
$$\therefore\quad \phi=\left(2B_0\hat{i}+3B_0\hat{j}+4B_0\hat{k}\right)\cdot\left(L^2\hat{k}\right)$$
$$\therefore\quad \phi=4B_0L^2$$

Question11

A long straight wire of radius ' r ' carries a steady current ' I '. The current is uniformly distributed over its cross-section. The ratio $\left(\frac{B}{B_1}\right)$ of the magnetic field ' B ' and ' B_1 ' at radial distances ' $\frac{r}{2}$ ' and ' $3r$ respectively, from the axis of the wire is

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Options:

A. $\frac{1}{2}$

B. $\frac{3}{2}$

C. $\frac{5}{2}$

D. $\frac{1}{2}$

Answer: B

Solution:

When the point is inside the wire,

By Ampere's Law:

B. $2\pi x=\mu_0 I_{\text{enclosed}}$

Since current is uniformly distributed, the current enclosed at radius x is :

$$\begin{aligned} I_{\text{enclosed}} & =I\left(\frac{\pi x^2}{\pi r^2}\right)=I\left(\frac{x^2}{r^2}\right) \\ \therefore \quad B \cdot 2\pi x & =\mu_0 I_{\text{enclosed}} \\ \therefore \quad B & =\frac{\mu_0 I x}{2\pi r^2} \end{aligned}$$

For outside the wire, entire I is enclosed so: $B_1 2\pi x.3\text{r}=\mu_0\text{I}$

$$\therefore B_1=\frac{\frac{\mu_0 I x}{2\pi r^2}}{\frac{\mu_0 I}{6\pi r}}$$
$$\therefore \frac{B}{B_1}=\frac{6x}{2r}$$
$$\therefore \frac{B}{B_1}=\frac{3}{2} \quad \ldots\left(\because x=\frac{r}{2}\right)$$

Question12

In hydrogen atom, an electron of charge 'e' revolves in an orbit of radius ' r ' with speed ' v '. The magnetic moment associated with electron is

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Options:

A. $\frac{\text{evr}}{3}$

B. $\frac{\text{evr}}{2}$

C. evr

D. $\sqrt{2}\text{evr}$

Answer: B

Solution:

Step 1: Current due to revolving electron

An electron going around in a circular orbit of radius r constitutes a current loop.

- Time period of revolution:

$$T = \frac{\text{circumference}}{\text{speed}} = \frac{2\pi r}{v}.$$

- Current:

$$I = \frac{\text{charge}}{\text{time period}} = \frac{e}{T} = \frac{e}{(2\pi r/v)} = \frac{ev}{2\pi r}.$$

Step 2: Magnetic moment formula

Magnetic moment of a current loop:

$\mu = I \cdot A,$

where A is area of loop: $A = \pi r^2$.

So:

$$\mu = \left(\frac{ev}{2\pi r}\right) \cdot \pi r^2 = \frac{evr}{2}.$$

Step 3: Match with options

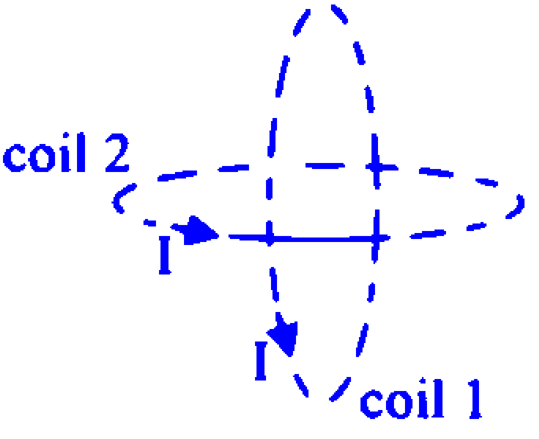
Thus, the associated magnetic moment is

$$\boxed{\frac{evr}{2}}$$

That corresponds to **Option B**.

Question13

Two current carrying identical coils are kept as shown in figure. The magnetic field at centre ' O ' is (N and R represent the number of turns and radius of each coil respectively, $\mu_0 =$ permeability of free space)



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Options:

A. $\frac{\mu_0 \mathrm{NI}}{2R}$

B. $\frac{\mu_0 N I}{\sqrt{2} R}$

C. $\frac{\mu_0 N I}{2 \sqrt{2} R}$

D. $\frac{\mu_0 \mathrm{~N}}{2}$

Answer: B

Solution:

$$B=\frac{\mu_0 N}{2 R} \sqrt{I_1^2+I_2^2}$$

$$\therefore \quad B=\frac{\mu_0 N I}{2 R} \sqrt{1^2+1^2}$$

$$\therefore \quad B=\frac{\mu_0 N I}{\sqrt{2} R}$$

Question14

The relation between magnetic moment (M) of a current carrying circular coil and length (L) of the wire used is

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Options:

A. $M \propto L$

B. $M \propto \frac{1}{L}$

C. $M \propto L^2$

D. $M \propto \frac{1}{L^2}$

Answer: C

Solution:

Step 1: Recall definition of magnetic moment

Magnetic moment of a current loop:

$M = I \cdot A$

where I is current and A is the area of the loop.

Step 2: Relating area with wire length

Suppose wire of length L is bent to form **one circular loop**.

Circumference of circle:

$2\pi r = L \quad \Rightarrow \quad r = \frac{L}{2\pi}$

So the area of the circle:

$A = \pi r^2 = \pi\left(\frac{L}{2\pi}\right)^2 = \frac{L^2}{4\pi}$

Step 3: Magnetic moment expression

$M = I \cdot A = I \cdot \frac{L^2}{4\pi}$

So,

$M \propto L^2 \quad$ (for fixed current I)

✅ **Final Answer:**

Option C: $M \propto L^2$

Question15

A square coil ABCD of side ' L ' is carrying a current in clockwise direction. A straight conductor carrying current I_2 (upward direction) is kept parallel to side AB at a distance $\frac{\mathrm{L}}{3}$ in the plane of $ABCD$. The net force on the coil ABCD is ($\mu_0 =$ magnetic permeability)

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Options:

A. $\frac{\mu_0 \mathrm{I}_1 \mathrm{I}_2}{3\pi}$

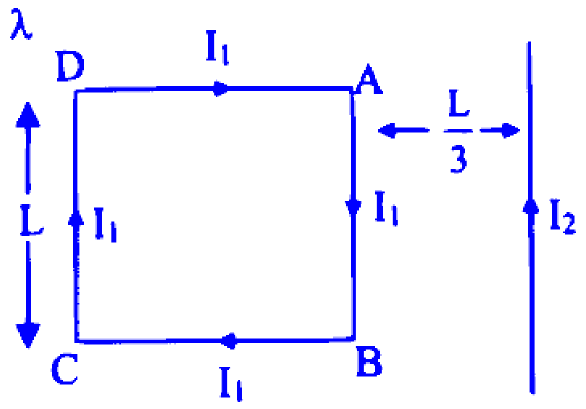
B. $\frac{3\mu_0 \mathrm{I}_1 \mathrm{I}_2}{4\pi}$

C. $\frac{3\mu_0 \mathrm{I}_1 \mathrm{I}_2}{8\pi}$

D. $\frac{9\mu_0 \mathrm{I}_1 \mathrm{I}_2}{8\pi}$

Answer: D

Solution:



Force on a segment of wire of length L at distance r from a long wire is:

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

Net force on loop $=$ sum of forces on all 4 sides

Side AB (distance $=\frac{L}{3}$) : (attractive)

$F_{AB}=\frac{\mu_0}{2\pi}\cdot\frac{I_1 I_2}{\frac{L}{3}}\cdot L=\frac{3\mu_0 I_1 I_2}{2\pi}$

Side CD (distance $=\frac{4L}{3}$) : (repulsive)

$F_{CD}=\frac{\mu_0}{2\pi}\cdot\frac{I_1 I_2}{\frac{4L}{3}}\cdot L=\frac{3\mu_0 I_1 I_2}{8\pi}$

Sides BC and AD :

forces cancel (equal \& opposite)

Net Force:

$$F_{Net}=F_{AB}-F_{CD}=\frac{3\mu_0 I_1 I_2}{2\pi}-\frac{3\mu_0 I_1 I_2}{8\pi}$$
$$\therefore F_{Net}=\frac{9\mu_0 I_1 I_2}{8\pi}$$

Question16

The magnetic field at the centre of a current carrying circular coil of area ' A ' is ' B '. The magnetic moment (M) of the coil is ($\mu_0=$ permeability of free space)

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Options:

A. $\frac{\mathrm{BA}^2}{\mu_0 \pi}$

B. $\frac{2BA^{3/2}}{\mu_0 \sqrt{\pi}}$

C. $\frac{BA^{3/2}}{\mu_0 \pi}$

D. $\frac{\mu_0 \sqrt{\pi}}{\mathrm{BA}^{3/2}}$

Answer: B

Solution:

Step 1: Recall formulas

- Magnetic field at the center of a circular coil of radius r carrying current I, with $N = 1$ turn:

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

- Magnetic moment:

$M = I \times A$

where $A = \pi r^2$.

Step 2: Express I in terms of B and r

$B = \frac{\mu_0 I}{2r} \quad \Rightarrow \quad I = \frac{2Br}{\mu_0}.$

Step 3: Express magnetic moment

$M = I \cdot A = \frac{2Br}{\mu_0} \cdot A.$

Step 4: Eliminate radius r using $A = \pi r^2$

$r = \sqrt{\frac{A}{\pi}}.$

Substitute:

$M = \frac{2B}{\mu_0} \cdot \sqrt{\frac{A}{\pi}} \cdot A.$

$M = \frac{2BA^{3/2}}{\mu_0 \sqrt{\pi}}.$

Final Answer:

Option B: $\frac{2BA^{3/2}}{\mu_0\sqrt{\pi}}$

Question17

Let the current ' I ' be associated with an electron of charge ' e ' moving in a circular orbit of radius ' r ' with speed ' v ' around the positively charged nucleus. The ratio $\frac{r}{v}$ is

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Options:

A. $\frac{\mathrm{eI}}{2\pi}$

B. $\frac{2\pi}{\mathrm{eI}}$

C. $\frac{\mathrm{e}}{2\pi\mathrm{I}}$

D. $\frac{2e\mathrm{I}}{\pi}$

Answer: C

Solution:

Step 1: Understand the physical situation

An electron of charge $-e$ is moving in a circular orbit of radius r with speed v.

This circulating charge produces a current I.

Step 2: Express current

Current is defined as charge per unit time:

$I = \frac{\text{charge passing a point}}{\text{time period}}$

The electron completes one revolution (circumference $2\pi r$) in time:

$T = \frac{2\pi r}{v}$

During this period, one full charge e circulates. So

$I = \frac{e}{T} = \frac{e}{\frac{2\pi r}{v}} = \frac{ev}{2\pi r}$

Step 3: Rearranging

$I = \frac{ev}{2\pi r}$

So,

$\frac{r}{v} = \frac{e}{2\pi I}$

Step 4: Match with given options

Option C: $\frac{e}{2\pi I}$

✓ Correct.

Final Answer:

$\frac{r}{v} = \frac{e}{2\pi I} \quad \Rightarrow \quad \text{Correct Option: C}$

Question18

A particle of charge q moves with a velocity $\overrightarrow{\mathrm{V}} = a\hat{\mathrm{i}}$ in a magnetic field $\overrightarrow{\mathrm{B}} = b\hat{\mathrm{j}} + c\hat{\mathrm{k}}$, where ' a ', ' b ' and ' c ' are constants. The magnitude of force experienced by particle is

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Options:

A. $qa\sqrt{b^2 + c^2}$

B. $\mathrm{qa}(\mathrm{b} + \mathrm{c})$

C. $qa\sqrt{b^2 - c^2}$

D. zero

Answer: A

Solution:

Magnetic force formula

$$\vec{F} = q(\vec{V} \times \vec{B})$$

$$\therefore \quad \vec{V} \times \vec{B} = a\hat{i} \times (b\hat{j} + c\hat{k})$$

$$= ab(\hat{i} \times \hat{j}) + ac(\hat{i} \times \hat{k})$$
$$= ab\hat{k} - ac\hat{j}$$

Magnitude of Force

$$|\overrightarrow{\mathrm{F}}| = q|\overrightarrow{\mathrm{V}} \times \overrightarrow{\mathrm{B}}|$$
$$= q\sqrt{(ab)^2 + (ac)^2}$$
$$= qa\sqrt{b^2 + c^2}$$

$\therefore$ Magnitude of Force $|\overrightarrow{\mathrm{F}}| = \mathrm{qa}\sqrt{\mathrm{b}^2 + \mathrm{c}^2}$

Question19

Two similar wires of equal lengths are bent in the form of a square and a circular loop. They are suspended in a uniform magnetic field and same current is passed through them. Torque experienced by

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Options:

A. circular loop is greater.

B. square loop is greater.

C. both loops is same.

D. both will be zero.

Answer: A

Solution:

Step 1: Formula for magnetic torque

For a planar current loop in a uniform magnetic field:

$\tau = mB\sin\theta$,

where $m = IA$ is the magnetic dipole moment,

I = current,

A = area of the loop.

So torque $\propto A$, since I, B are the same.

Step 2: Length constraint

Let the wire length be L.

- **Square loop:**

  Perimeter = $L = 4a$. So side = $a = \frac{L}{4}$.

  Area = $A_{\text{sq}} = a^2 = \left(\frac{L}{4}\right)^2 = \frac{L^2}{16}$.

- **Circular loop:**

  Circumference = $L = 2\pi r \implies r = \frac{L}{2\pi}$.

  Area = $A_{\text{cir}} = \pi r^2 = \pi\left(\frac{L}{2\pi}\right)^2 = \frac{L^2}{4\pi}$.

Step 3: Compare areas

We need to compare:

$$\frac{A_{\text{cir}}}{A_{\text{sq}}} = \frac{\frac{L^2}{4\pi}}{\frac{L^2}{16}} = \frac{16}{4\pi} = \frac{4}{\pi} \approx 1.27.$$

So,

$A_{\text{cir}} > A_{\text{sq}}$.

Step 4: Conclusion

Since torque $\tau \propto A$ (for same I, B, θ),

$\tau_{\text{cir}} > \tau_{\text{sq}}$.

✅ **Answer: Option A — Circular loop is greater.**

Question20

A wire of length L carries current I along x - axis. A magnetic field $\vec{B} = B_0(\hat{i} - \hat{j} - \hat{k})T$ acts on the wire. The magnitude of magnetic force acting on the wire is

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Options:

A. $\frac{\mathrm{ILB_0}}{2}$

B. $\mathrm{ILB_0}$

C. $2ILB_0$

D. $\sqrt{2}\mathrm{ILB_0}$

Answer: D

Solution:

Step 1. Recall formula

Force on current carrying conductor of length vector $\vec{L}$ in magnetic field $\vec{B}$:

$$\vec{F} = I\,(\vec{L} \times \vec{B})$$

Here, I is current, $\vec{L}$ is the vector along the wire (magnitude = physical length, direction = current).

Step 2. Identify given vectors

- Wire along x-axis, current along $+\hat{i}$.

So:

$$\vec{L} = L\hat{i}$$

- Magnetic field:

$$\vec{B} = B_0(\hat{i} - \hat{j} - \hat{k})$$

Step 3. Compute cross product

$$\vec{L} \times \vec{B} = L\hat{i} \times \left[B_0(\hat{i} - \hat{j} - \hat{k})\right] = LB_0\left(\hat{i} \times \hat{i} - \hat{i} \times \hat{j} - \hat{i} \times \hat{k}\right)$$

- $\hat{i} \times \hat{i} = 0$
- $\hat{i} \times \hat{j} = \hat{k}$
- $\hat{i} \times \hat{k} = -\hat{j}$

So:

$\vec{L} \times \vec{B} = LB_0\big(0 - \hat{k} - (-\hat{j})\big) = LB_0(\hat{j} - \hat{k})$

Thus:

$\vec{F} = I(\vec{L} \times \vec{B}) = ILB_0(\hat{j} - \hat{k})$

Step 4. Magnitude

$|\vec{F}| = ILB_0\sqrt{1^2 + (-1)^2} = ILB_0\sqrt{2}$

Final Answer:

$\boxed{\sqrt{2}\, ILB_0}$

Correct option: D. ✅

Question21

A circular coil of wire consisting of ' n ' tums each of radius 8 cm carries a current of 0.4 A . The magnitude of the magnetic field at the centre of coil is 3.14×10^{-4} T. The value of ' n ' is

[Take $\mu_0 = 12.56 \times 10^{-7}$ SI unit]

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Options:

A. 1

B. 10

C. 100

D. 1000

Answer: C

Solution:

For a circular coil of radius R, carrying a current I, with n turns:

$B = \frac{\mu_0 n I}{2R}$

Step 2: Substitute known values

- $\mu_0 = 12.56 \times 10^{-7}$ H/m
- Radius: $R = 8$ cm $= 0.08$ m
- Current: $I = 0.4$ A
- Magnetic field: $B = 3.14 \times 10^{-4}$ T

Step 3: Rearrange for n

$n = \frac{2RB}{\mu_0 I}$

Step 4: Plug in numbers

$n = \frac{2 \times 0.08 \times 3.14 \times 10^{-4}}{(12.56 \times 10^{-7})(0.4)}$

First, numerator:

$2 \times 0.08 = 0.16, \quad 0.16 \times 3.14 \times 10^{-4} = 0.5024 \times 10^{-4} = 5.024 \times 10^{-5}$

Denominator:

$12.56 \times 10^{-7} \times 0.4 = 5.024 \times 10^{-7}$

So,

$n = \frac{5.024 \times 10^{-5}}{5.024 \times 10^{-7}} = 100$

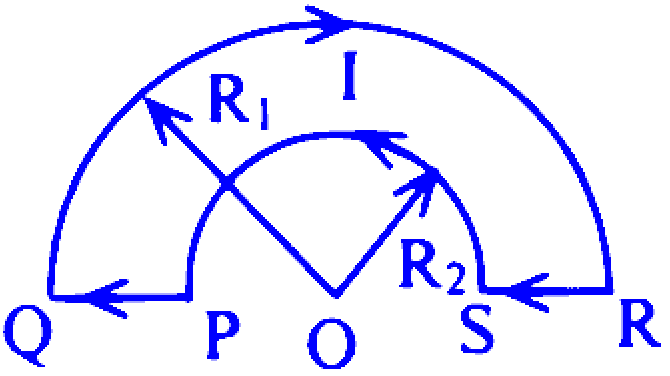
✅ **Final Answer:**

The number of turns is

Option C: 100

Question22

The wire loop PQRSP formed by joining two semicircular wire of radii R_1 and R_2 carries a current I as shown. The magnitude of the magnetic field at the centre ' O ' is



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Options:

A. $\frac{\mu_0 I}{4}\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

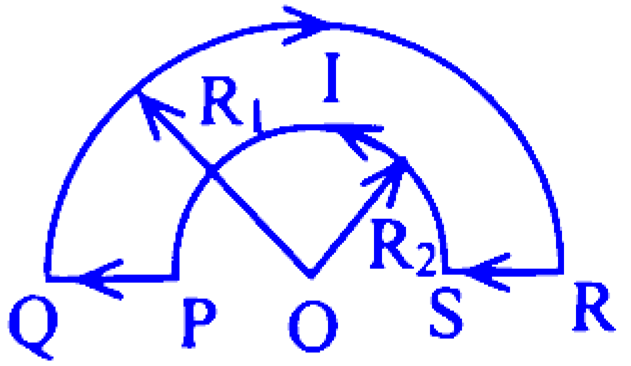
B. $\frac{\mu_0 \mathrm{I}}{4}\left[\frac{1}{\mathrm{R}_2}-\frac{1}{\mathrm{R}_1}\right]$

C. $\frac{\mu_0 I}{2\pi}\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

D. $\frac{\mu_0 \mathrm{I}}{2\pi}\left[\frac{1}{\mathrm{R}_2}-\frac{1}{\mathrm{R}_1}\right]$

Answer: B

Solution:



Magnetic induction at point O is zero due to the straight current portions of QP and SP .Magnetic Field at point O due to semicircular wire QR :

$B_1=\frac{1}{2}\left(\frac{\mu_0 I}{2R_1}\right)$

Magnetic Field at point O due to semicircular wire SP:

$B_2 = \frac{1}{2}\left(\frac{\mu_0 I}{2R_2}\right)$

Since the direction of current in both the wires is opposite to each other, the net magnetic field at point O :

$$B_{net} = B_2 - B_1 = \frac{1}{2}\left(\frac{\mu_0 I}{2R_2}\right) - \frac{1}{2}\left(\frac{\mu_0 I}{2R_1}\right)$$
$$\therefore B_{net} = \frac{\mu_0 I}{4}\left[\frac{1}{R_2} - \frac{1}{R_1}\right]T$$

Question23

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

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Options:

A. $\frac{B_1}{9}$

B. $9B_1$

C. 3 B_1

D. $\frac{B_1}{3}$

Answer: A

Solution:

We are asked about the magnetic field at the center of a circular current-carrying coil when the number of turns is changed.

Step 1: Formula for field

For a circular coil of radius R, carrying current I, the magnetic field at the center due to **one turn** is

$B = \frac{\mu_0 I}{2R}$.

For N turns (closely wound):

$B = \frac{\mu_0 NI}{2R}$.

So $B \propto \frac{N}{R}$.

Step 2: Initial case

Initially:

- $N_1 = 9$,
- Suppose the length of wire used = L.

Circumference of one turn = $2\pi R_1$.

So $L = N_1 \cdot 2\pi R_1 = 9 \cdot 2\pi R_1$.

Thus

$R_1 = \frac{L}{18\pi}$.

Magnetic field

$B_1 = \frac{\mu_0 N_1 I}{2R_1}$.

Step 3: Second case

Rewound into 3 turns, same wire length L.

Now circumference per turn = $2\pi R_2$.

So $L = N_2 \cdot 2\pi R_2 = 3 \cdot 2\pi R_2$.

Thus

$R_2 = \frac{L}{6\pi}$.

Field

$B_2 = \frac{\mu_0 N_2 I}{2R_2}$.

Step 4: Ratio B_2/B_1

$$\frac{B_2}{B_1} = \frac{\frac{\mu_0 N_2 I}{2R_2}}{\frac{\mu_0 N_1 I}{2R_1}} = \frac{N_2/R_2}{N_1/R_1} = \frac{N_2 R_1}{N_1 R_2}.$$

Now plug in numbers:

$R_1 = \frac{L}{18\pi}, \quad R_2 = \frac{L}{6\pi}$.

So

$$\frac{R_1}{R_2} = \frac{L/(18\pi)}{L/(6\pi)} = \frac{1}{3}.$$

Thus

$$\frac{B_2}{B_1} = \frac{N_2}{N_1} \cdot \frac{R_1}{R_2} = \frac{3}{9} \cdot \frac{1}{3} = \frac{1}{9}.$$

So

$B_2 = \frac{B_1}{9}$.

✅ **Final Answer:**

Option A: $\frac{B_1}{9}$

Question24

An electron moves in Bohr orbit. The magnetic field at the centre is proportional to

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Options:

A. n^{-2}

B. n^{-3}

C. n^{-4}

D. n^{-5}

Answer: D

Solution:

Step 1: Magnetic field at centre due to revolving electron

The electron in orbit acts like a current loop.

- Current:

$I = \frac{e}{T} = \frac{ev}{2\pi r}$

- Magnetic field at centre of a current loop of radius r:

$B = \frac{\mu_0 I}{2r} = \frac{\mu_0}{2r} \cdot \frac{ev}{2\pi r} = \frac{\mu_0 ev}{4\pi r^2}$

So:

$B \propto \frac{v}{r^2}$.

Step 2: Relation between v, r, n in Bohr model

- Bohr radius relation:

$r_n = n^2 a_0 \quad \Rightarrow \quad r \propto n^2$

- Velocity:

$v_n = \frac{v_1}{n} \quad \Rightarrow \quad v \propto \frac{1}{n}.$

Step 3: Substitute

$B \propto \frac{v}{r^2} \propto \frac{1/n}{(n^2)^2} = \frac{1}{n^5}.$

✅ **Final Answer:**

$\boxed{n^{-5}}$

Correct Option: D.

Question25

Two long parallel wires carry currents I_1 and I_2 $(\mathrm{I}_1 > \mathrm{I}_2)$. When currents are flowing in the same direction, the magnetic field at a point midway between the wires is 6×10^{-6} T. If the direction of I_2 is reversed the field at midpoint becomes 3×10^{-5} T. The ratio $\mathrm{I}_1 : \mathrm{I}_2$ is

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Options:

A. 3 : 2

B. 2 : 3

C. 3 : 5

D. 6 : 7

Answer: A

Solution:

- Case 1: **Same direction of currents** → At midpoint, fields subtract because the fields produced by each wire at the midpoint are in **opposite directions**. Net field =

$B = \frac{\mu_0}{2\pi d}(I_1 - I_2) = 6 \times 10^{-6}$ T

- Case 2: **Reversing I_2** → Now the fields at midpoint are **in the same direction**. So net field =

$B = \frac{\mu_0}{2\pi d}(I_1 + I_2) = 3 \times 10^{-5}$ T

Step 1: Write equations

Let

$k = \frac{\mu_0}{2\pi d}$

Then,

$k(I_1 - I_2) = 6 \times 10^{-6}$

$k(I_1 + I_2) = 3 \times 10^{-5}$

Step 2: Divide the two equations

$\frac{I_1 - I_2}{I_1 + I_2} = \frac{6\times10^{-6}}{3\times10^{-5}} = \frac{6}{30} = \frac{1}{5}$

So:

$I_1 - I_2 = \frac{1}{5}(I_1 + I_2)$

Step 3: Solve ratio

Multiply across:

$5(I_1 - I_2) = I_1 + I_2$

$5I_1 - 5I_2 = I_1 + I_2$

$4I_1 = 6I_2$

$\frac{I_1}{I_2} = \frac{6}{4} = \frac{3}{2}$

So the ratio:

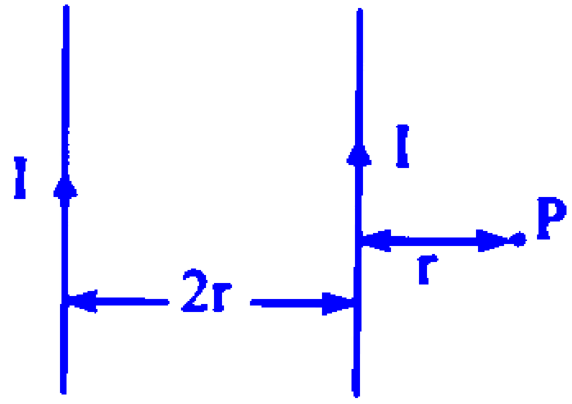
$I_1 : I_2 = 3 : 2$

✅ **Answer: Option A** (3 : 2)

Question26

Two very long straight conductors (wires) are set parallel to each other. Each carries a current ' I ' in the same direction and the separation between them is ' 2 r '. The intensity of the magnetic field

at point ' P ' (as shown in the figure) (μ_0 = permeability of free space) is



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Options:

A. $\frac{2}{3} \frac{\mu_0 I}{\pi r}$

B. $\frac{3}{8} \frac{\mu_0 I}{\pi \pi}$

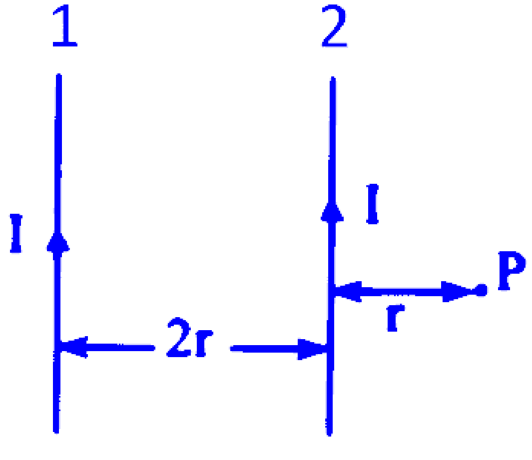
C. $\frac{1}{4} \frac{\mu_0 \mathrm{I}}{\pi \mathrm{r}}$

D. $\frac{\mu_0 I}{2 \pi r}$

Answer: A

Solution:

In the figure, magnetic field at point P is given by,



$$\begin{aligned} B_{net} &= B_1 + B_2 \\ &= \frac{\mu_0 I}{2\pi} \times \left(\frac{1}{r} + \frac{1}{3r}\right) \\ &= \frac{\mu_0 I}{2\pi} \times \left(\frac{4}{3r}\right) \\ &= \frac{2}{3} \frac{\mu_0 I}{\pi r} \end{aligned}$$

Question27

Two identical long parallel wires carry currents ' I_1 ' and ' I_2 ' such that $I_1 > I_2$. When the currents are in the same direction, the magnetic field at a point midway between the wires is 8×10^{-6} T. If the direction of I_2 is reversed, the field becomes 3.2×10^{-5} T. The ratio of I_2 to I_1 is

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Options:

A. $1 : 4$

B. $2 : 5$

C. $3 : 5$

D. $3 : 4$

Answer: C

Solution:

Let the distance between the two wires be $2a$.

Let the currents be I_1 and I_2 with $I_1 > I_2$.

The point midway between the wires is at distance a from each wire.

Case 1: Currents in the same direction

Magnetic field due to a long straight wire at distance a is

$B=\frac{\mu_0 I}{2\pi a}$

At the midway point, both fields are perpendicular and add/subtract depending on direction.

Since the currents are in the same direction, at the midway point the fields due to both wires are in opposite direction, so

$B_1=\frac{\mu_0 I_1}{2\pi a} B_2=\frac{\mu_0 I_2}{2\pi a}$

Net field:

$B_{\text{net }}=B_1-B_2=\frac{\mu_0}{2\pi a}\left(I_1-I_2\right)$

Given:

$B_{\text{net }}=8\times 10^{-6}\ \mathrm{T}$

Case 2: Currents in opposite direction

Now, at the midpoint, fields due to both wires are in the same direction, so

$B_{\text{net }}^{\prime}=B_1+B_2=\frac{\mu_0}{2\pi a}\left(I_1+I_2\right)$

Given:

$B_{\text{net }}^{\prime}=3.2\times 10^{-5}\ \mathrm{T}$

Now, form the equations:

1) $I_1-I_2=A$

2) $I_1+I_2=B$

Where $A=\dfrac{2\pi a}{\mu_0}\times 8\times 10^{-6}, B=\dfrac{2\pi a}{\mu_0}\times 3.2\times 10^{-5}$

But $\dfrac{2\pi a}{\mu_0}$ cancels if we take the ratio.

So,

$\frac{I_1+I_2}{I_1-I_2}=\frac{B_{\text{opposite}}}{B_{\text{same}}}$

Plug values:

$\frac{I_1+I_2}{I_1-I_2}=\frac{3.2\times 10^{-5}}{8\times 10^{-6}}=\frac{32}{8}=4$

Let $x=I_2/I_1$.

Let $I_1-I_2=y$.

Then $I_1+I_2=4y$

Adding:

$I_1 + I_2 = 4y$

$I_1 - I_2 = y$

Add: $2I_1 = 5y \implies I_1 = \frac{5y}{2}$

Subtract: $2I_2 = 3y \implies I_2 = \frac{3y}{2}$

So,

$\frac{I_2}{I_1} = \frac{\frac{3y}{2}}{\frac{5y}{2}} = \frac{3}{5}$

Answer:

$$\boxed{\frac{I_2}{I_1} = \frac{3}{5}}$$

The correct option is **Option C:** 3 : 5.

Question28

An element $\overrightarrow{\Delta l} = \Delta \mathrm{xi}$ is placed at the origin and carries a current of 10 A . The magnitude of magnetic field on the Y axis at a distance of 0.5 m if $\Delta x = 1$ cm is $\left(\frac{\mu_0}{4\pi} = 10^{-7}\right.$ SI unit $\left.\right)$ $(\sin 90^\circ = 1)$

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Options:

A. 2×10^{-7} T

B. 10^{-8} T

C. 4×10^{-8} T

D. 2×10^{-8} T

Answer: C

Solution:

Given:

- Element $\overrightarrow{\Delta l} = \Delta x\,\hat{i}$ at the origin,
- Current, $I = 10\,\text{A}$
- Position for the magnetic field: $(0,\ 0.5,\ 0)$ (i.e., on Y-axis, $r = 0.5\,\text{m}$)
- $\Delta x = 1\,\text{cm} = 0.01\,\text{m}$
- $\dfrac{\mu_0}{4\pi} = 10^{-7}$ SI units
- $\sin 90^\circ = 1$

Step 1: Biot-Savart Law for a Small Element

The magnetic field at point P due to a small current element is:

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

Step 2: Set Up the Cross Product

- $d\vec{l} = \Delta x\,\hat{i}$
- $\vec{r} = 0\,\hat{i} + 0.5\,\hat{j} + 0\,\hat{k}$

  So,
- $\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \hat{j}$
- Angle between $d\vec{l}$ and $\vec{r}$ is 90° (since $d\vec{l}$ along x, $\vec{r}$ along y).

So,

$d\vec{l} \times \hat{r} = \Delta x\,\hat{i} \times \hat{j} = \Delta x\,\hat{k}$

Step 3: Calculate the Magnitude of dB

$dB = \frac{\mu_0}{4\pi}\frac{I\,\Delta x \sin 90^\circ}{r^2}$

$dB = \frac{\mu_0}{4\pi}\frac{I\,\Delta x}{r^2}$

Substitute values:

- $I = 10\,\text{A}$
- $\Delta x = 0.01\,\text{m}$
- $r = 0.5\,\text{m}$

- $\frac{\mu_0}{4\pi} = 10^{-7}$

$dB = 10^{-7} \times \frac{10 \times 0.01}{(0.5)^2}$

$dB = 10^{-7} \times \frac{0.1}{0.25}$

$dB = 10^{-7} \times 0.4$

$dB = 4 \times 10^{-8}\ \mathrm{T}$

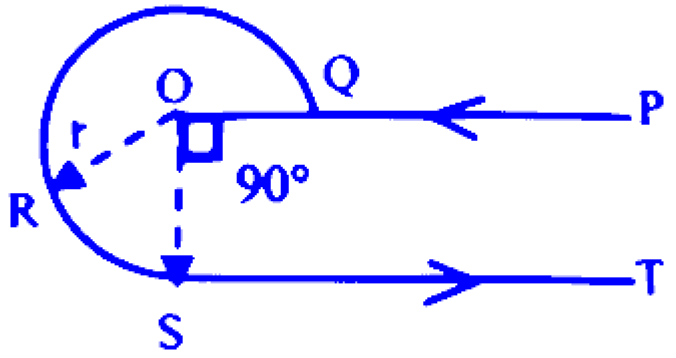
Correct option:

$\boxed{4 \times 10^{-8}\ \mathrm{T}}$

So the answer is **Option C**.

Question29

A current ' I ' is flowing in a conductor PQRST as shown in figure. The radius of curved path QRS is ' R ' and length of straight portion PQ and ST is very large. The magnetic field at the centre $[\mathrm{O}]$ of the curved part is ($\mu_0 =$ permeability of free space)



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Options:

A. $\frac{\mu_0 \mathrm{i}}{4\pi \mathrm{r}}\left(\frac{3\pi}{2} + 1\right)(-\hat{\mathrm{k}})$

B. $\frac{\mu_0 \mathrm{i}}{4\pi \mathrm{r}}\left(\frac{3\pi}{2} + 1\right)\hat{\mathrm{k}}$

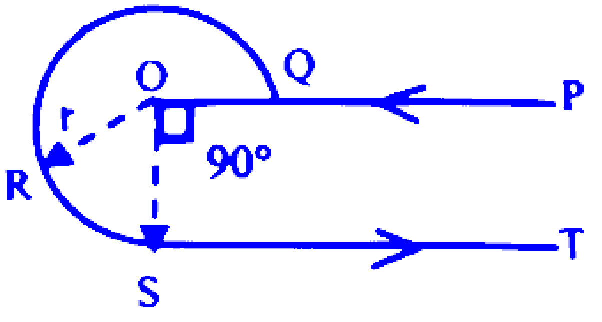
C. $\frac{\mu_0 i}{4\pi r}\left[\frac{3\pi}{2}-1\right](-\hat{k})$

D. $\frac{\mu_0 i}{4\pi r}\left[\frac{3\pi}{2}-1\right]\hat{k}$

Answer: B

Solution:

The angle subtended by the circular part QRS at the centre is $3\pi/2$.



Field due to QRS,

$B_1=\frac{\mu_0}{4\pi}\frac{I}{r}\left(\frac{3\pi}{2}\right)$

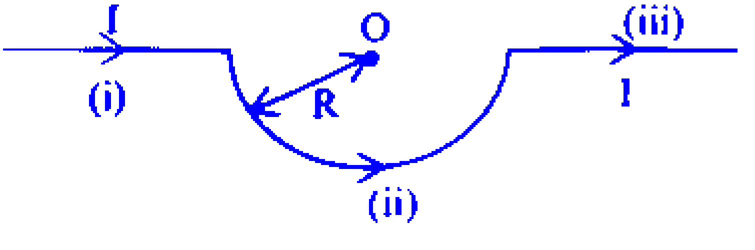
Field due to PQ at O ,

$$B_2=\frac{\mu_0}{2\pi r}\times\frac{I}{2}=\frac{\mu_0 I}{4\pi r}\ldots[\because \text{T is at the end of the wire}]$$

$\therefore$ Total induction $=\frac{\mu_0 I}{4\pi r}\left(\frac{3\pi}{2}+1\right)\hat{k}$

Question30

A wire has three different sections as shown in figure. The magnitude of the magnetic field produced at the centre ' O ' of the semicircle by three sections together is ($\mu_0=$ permiability of free space)



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Options:

A. $\frac{\mu_0 \mathrm{I}}{4\mathrm{R}}$

B. $\frac{\mu_0 \mathrm{I}}{2\mathrm{R}}$

C. $\frac{\mu_0 \mathrm{I}}{4\pi\mathrm{R}}$

D. $\frac{\mu_0 I}{2\pi R}$

Answer: A

Solution:

Let's analyse each wire section's contribution to magnetic field at centre O:

1. Straight Segment AB

For a straight wire passing through the centre, and with infinite length, field at the centre is **zero** by symmetry because the contributions from both sides cancel. The segment AB is straight and passes directly through O, so:

$B_{AB} = 0$

2. Semicircular Section BC

Magnetic field at centre, due to a current I in a **semicircular arc of radius** R is:

$B_{BC} = \frac{\mu_0 I}{4R}$

Direction: Using **right hand rule**, direction is **into the page** (or use NCERT convention, if you imagine current flowing from B to C).

3. Straight Segment CD

Again, this is a straight segment passing through O, so its field at O is:

$B_{CD} = 0$

4. Total Magnetic Field at O

Adding all three contributions:

$$B_{\text{total}} = B_{AB} + B_{BC} + B_{CD} = 0 + \frac{\mu_0 I}{4R} + 0 = \boxed{\frac{\mu_0 I}{4R}}$$

Correct Option:

Option A: $\frac{\mu_0 I}{4R}$

Question31

A long wire carrying a steady current is bent into a circle of single turn. The magnetic field at the centre of the coil is ' B '. If it is bent into a circular loop of radius ' r_1 ' having ' n ' turns, the magnetic field at the centre of the coil for same current is

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Options:

A. $\frac{B}{n^2}$

B. $\frac{B}{n}$

C. $n^2 B$

D. nB

Answer: C

Solution:

Let the length of the wire be L.

1. **Single Turn:**

- When the wire is bent into a single circle of radius r, its length is $L = 2\pi r$.
- Magnetic field at the center of a single-turn circle:

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

1. **'n' Turns:**

- If the same wire is bent into n turns, each of radius r_1, the total length must remain the same:

  $L = n \times 2\pi r_1$

  $2\pi r = n \times 2\pi r_1 \implies r = n r_1$

- Magnetic field at the center of n-turn loop (radius r_1):

  $B' = n \times \left(\frac{\mu_0 I}{2r_1}\right)$

1. **Relate B' and B:**

- From above, $r = nr_1$ and $B = \frac{\mu_0 I}{2r}$:

  $B = \frac{\mu_0 I}{2r} = \frac{\mu_0 I}{2nr_1}$

- Therefore,

  $\frac{\mu_0 I}{2r_1} = nB$

- So,

  $B' = n\left(\frac{\mu_0 I}{2r_1}\right) = n(nB) = n^2 B$

Correct answer:

$\boxed{n^2 B}$

So, Option C is correct.

Question32

A particle carrying a charge equal to 1000 times the charge on an electron, is rotating one rotation per second in a circular path of radius ' r ' m. If the magnetic field produced at the centre of the path is x times the permeability of vacuum, the radius ' r ' in m is $\left[\mathrm{e} = 1.6 \times 10^{-19} \mathrm{C}\right] \left[\mathrm{x} = 2 \times 10^{-16}\right]$

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Options:

A. 0.04

B. 0.02

C. 0.2

D. 0.4

Answer: D

Solution:

Given:

- Charge on the particle, $q = 1000 \times e = 1000 \times 1.6 \times 10^{-19}\ \text{C}$
- Frequency of rotation, $f = 1\ \text{Hz}$
- Radius of path, r (to be found)
- Magnetic field at centre, $B = x\mu_0$ where $x = 2 \times 10^{-16}$
- μ_0 is the permeability of vacuum

Step 1: Formula for Magnetic Field at the Centre

When a charge q moves in a circle of radius r with frequency f, it makes current I:

$I = q \times f$

Magnetic field at centre of the circle:

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

Substitute I:

$B = \frac{\mu_0 q f}{2r}$

Step 2: Substitute Values

Given $B = x\mu_0$:

$x\mu_0 = \frac{\mu_0 q f}{2r}$

μ_0 cancels out:

$x = \frac{qf}{2r}$

Step 3: Rearrangement for r

$r = \frac{qf}{2x}$

Step 4: Substitute q, f, and x

$q = 1000 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-16}\ \text{C}$

$f = 1\ \text{Hz}$

$x = 2 \times 10^{-16}$

Substituting,

$r = \frac{1.6 \times 10^{-16} \times 1}{2 \times 2 \times 10^{-16}}$

$r = \frac{1.6 \times 10^{-16}}{4 \times 10^{-16}}$

$r = \frac{1.6}{4}$

$r = 0.4 \text{ m}$

Answer:

Option D: 0.4

Question33

Bohr model is applied to a particle of mass m and charge q is moving in a plane under the influence of a transverse magnetic field (B). The energy of the charged particle in the second level will be ($\mathrm{h} =$ Planck's constant)

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Options:

A. $\frac{\mathrm{qBh}}{\pi \mathrm{m}}$

B. $\frac{\mathrm{q}^2 \mathrm{~B}^2 \mathrm{~h}^2}{4 \pi \mathrm{~m}}$

C. $\frac{\mathrm{qBh}}{2 \pi \mathrm{~m}}$

D. $\frac{2 q \mathrm{Bh}}{\pi m}$

Answer: C

Solution:

Let's solve this problem step-by-step as per the NCERT approach:

Step 1: Force on a Particle in Magnetic Field

A particle of charge q moving with velocity v perpendicular to a magnetic field B experiences a force:

$F = qvB$

This acts as the centripetal force:

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

So,

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

Step 2: Bohr's Angular Momentum Quantization

According to Bohr's quantization:

$mvr = n\hbar \quad \text{where } \hbar = \frac{h}{2\pi}, \text{ and } n = 1, 2, 3, \ldots$

Substitute the value of v:

$m\left(\frac{qBr}{m}\right)r = n\hbar$

$qBr^2 = n\hbar$

$r^2 = \frac{n\hbar}{qB}$

$r = \sqrt{\frac{n\hbar}{qB}}$

Step 3: Kinetic Energy of the Particle (since only magnetic force is acting)

Kinetic energy,

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

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

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

Substitute r^2 from above:

$KE = \frac{q^2B^2}{2m}\left(\frac{n\hbar}{qB}\right)$

$= \frac{qBn\hbar}{2m}$

Step 4: For the Second Level ($n = 2$)

Substitute $n = 2$:

$KE = \frac{qB \cdot 2\hbar}{2m} = \frac{qB\hbar}{m}$

Recall, $\hbar = \frac{h}{2\pi}$:

$KE = \frac{qB}{m} \cdot \frac{h}{2\pi}$

$KE = \frac{qBh}{2\pi m}$

Step 5: Final Answer

So, the energy of the charged particle in the second level is:

$$\boxed{\frac{qBh}{2\pi m}}$$

Correct option: Option C

Question34

Two long conductors separated by a distance ' d ' carry currents ' I_1 ' and ' I_2 ' in the same directions. They exert a force ' F ' on each other. The distance between them is increased to ' 3 d '. If new repulsive force of magnitude ' $\frac{2}{3}$ F ' is found between these conductors, the required change in the magnitude and direction of one of the currents in the conductor is respectively [length of the conductors is constant]

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Options:

A. same, reversed.

B. twice, reversed.

C. thrice, same.

D. twice, same.

Answer: B

Solution:

Let us solve step by step as per NCERT methods:

Step 1: Force Between Two Parallel Currents

The force per unit length between two long, straight, parallel conductors separated by distance d carrying currents I_1 and I_2 is

$F = \frac{\mu_0}{4\pi} \cdot \frac{2I_1I_2}{d} \cdot L$

where L is the length of the conductors.

(Since the conductors are long, we can write $F \propto \frac{I_1 I_2}{d}$.)

Step 2: Given Data

- Initial distance = d
- Force = F
- Final distance = $3d$
- New force = $\dfrac{2}{3}F$

Step 3: Expression for Initial and Final Force

Initial force:

$F = k \cdot \frac{I_1 I_2}{d}$

Final force (distance is $3d$, assume new current in one conductor becomes I_2'):

$F' = k \cdot \frac{I_1 I_2'}{3d}$

where k contains constants and length.

Step 4: Use the Ratio

Given:

$F' = \frac{2}{3}F$

So,

$k \cdot \frac{I_1 I_2'}{3d} = \frac{2}{3}\left[k \cdot \frac{I_1 I_2}{d}\right]$

Step 5: Cancel Constants and Simplify

- Cancel k, I_1, and d (they are all non-zero):

$\frac{I_2'}{3} = \frac{2}{3} I_2$

$I_2' = 2I_2$

Step 6: Direction of Force

- Originally, currents were in the **same direction** (force was **attractive**, not repulsive).
- The question now mentions the force is **repulsive**.

Recall:

- Currents in the **same direction**: **Attract**.
- Currents in **opposite directions**: **Repel**.

So, to make the force **repulsive**, the direction of one current must be **reversed**.

Step 7: Final Answers

- **Change in current magnitude:** It becomes **twice** ($2I_2$).
- **Direction: Reversed**.

Final Answer:

Option B: twice, reversed.

Question35

Two long parallel wires carrying currents 4 A and 3 A in opposite directions are placed at a distance of 5 cm from each other. A point P is at equidistance from both the wires such that the line joining the point P to the wires are perpendicular to each other. The magnitude of magnetic field at point P is($\mu_0 =$ permeability of free space $= 4\pi \times 10^{-7}$ SI unit)

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Options:

A. 4×10^{-5} T

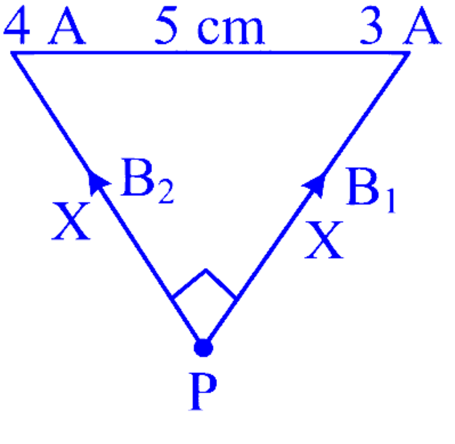
B. $\sqrt{2} \times 10^{-5}$ T

C. 2×10^{-5} T

D. $2\sqrt{2} \times 10^{-5}$ T

Answer: D

Solution:



Magnetic field produced by two wires

$B_1 = \frac{\mu_0 I_1}{2\pi X}$ and $B_2 = \frac{\mu_0 I_2}{2\pi X}$

From Figure,

$B_{net} = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0}{2\pi X}\sqrt{I_1^2 + I_2^2}$

Also using Pythagoras theorem, $2X^2 = 5 \times 5$

Solution:

1. **Angular Momentum (L):**

For an electron revolving in a circular orbit,

$\therefore X = \frac{5}{\sqrt{2}}$ cm

$$B_{net} = \frac{4\pi \times 10^{-7}}{2\pi \times \frac{5}{\sqrt{2}} \times 10^{-2}}\sqrt{4^2 + 3^2} = 2\sqrt{2} \times 10^{-5}\ \mathrm{T}$$

Question36

The ratio of angular momentum L of an electron to the magnetic dipole moment $\overrightarrow{m}_{orb}$ is (' m ' is mass of electron, ' e ' is charge on electron)

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Options:

A. $\frac{e}{m}$

B. $\frac{2m}{e}$

C. $\frac{e}{2\,m}$

D. $\frac{m}{e}$

Answer: B

Solution:

1. **Angular Momentum (L):**

   For an electron revolving in a circular orbit,

$L = mvr$

where m is the mass, v is the velocity, and r is the radius.

2. **Orbital Magnetic Dipole Moment (m_{orb}):**

   Current due to electron motion is $I = \frac{e}{T} = \frac{ev}{2\pi r}$

   Area of orbit $A = \pi r^2$

   So,

   $$m_{\text{orb}} = I \times A = \left(\frac{ev}{2\pi r}\right) \times (\pi r^2) = \frac{evr}{2}$$

3. **Finding the ratio $\frac{L}{m_{\text{orb}}}$:**

   $$\frac{L}{m_{\text{orb}}} = \frac{mvr}{\left(\frac{evr}{2}\right)} = \frac{mvr}{\frac{evr}{2}} = \frac{mvr \times 2}{evr} = \frac{2m}{e}$$

So, the correct answer is:

$$\boxed{\frac{2m}{e}}$$

This matches **Option B**.

Question37

Two long straight wires A and B carrying equal current 'I' were kept parallel to each other at distance ' d ' apart. Magnitude of magnetic force experienced by length L of wire A is ' F '. If the distance between the wires is made half and currents are doubled, force F_2 on length L of wire A will be

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Options:

A. 2F

B. F

C. 8F

D. 4F

Answer: C

Solution:

Let the initial current in each wire be I, and the distance between wires be d.

Step 1: Magnetic force between parallel currents

The force per unit length between two long, parallel wires carrying currents I_1 and I_2, separated by distance r, is:

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

So,

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

Step 2: Write the original force (F)

Here, $I_1 = I_2 = I$, $r = d$, so

$F = \frac{\mu_0}{2\pi}\frac{I^2}{d}L$

Step 3: New situation

- New distance = $\frac{d}{2}$
- New current = $2I$ for each wire

New force: F_2

$F_2 = \frac{\mu_0}{2\pi}\frac{(2I)\cdot(2I)}{d/2}L$

Step 4: Simplify numerator and denominator

$F_2 = \frac{\mu_0}{2\pi}\frac{4I^2}{d/2}L = \frac{\mu_0}{2\pi}\frac{4I^2 \times 2}{d}L = \frac{\mu_0}{2\pi}\frac{8I^2}{d}L$

Step 5: Compare F_2 and F

Recall:

$F = \frac{\mu_0}{2\pi}\frac{I^2}{d}L$

So,

$F_2 = 8F$

Final Answer:

Option C: $8F$

Question38

An arc of a circle of radius ' R ' subtends an angle $\frac{\pi}{2}$ at the centre. It carries a current I. The magnetic field at the centre will be ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 I}{2R}$

B. $\frac{\mu_0 I}{8R}$

C. $\frac{\mu_0 I}{4R}$

D. $\frac{2\mu_0 I}{5R}$

Answer: B

Solution:

The magnetic field due to a current-carrying circular arc can be calculated using the formula:

$B = \frac{\mu_0 I}{2R}\left(\frac{\theta}{2\pi}\right)$

In this scenario, the angle subtended by the arc at the center is $\theta = \frac{\pi}{2}$.

Substituting the given value of θ into the formula, we calculate the magnetic field as follows:

$$B = \frac{\mu_0 I}{2R}\left(\frac{1}{2\pi} \times \frac{\pi}{2}\right)$$
$$= \frac{\mu_0 I}{2R}\left(\frac{1}{4}\right)$$
$$= \frac{\mu_0 I}{8R}$$

Thus, the magnetic field at the center due to the arc is $\frac{\mu_0 I}{8R}$.

Question39

A current 'I' flows in anticlockwise direction in a circular arc of a wire having $\left(\frac{3}{4}\right)^{\text{th}}$ of circumference of a circle of radius R. The magnetic field ' B ' at the centre of circle is ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 \mathrm{I}}{3\mathrm{R}}$ in upward direction

B. $\frac{\mu_0 I}{2R}$ in downward direction

C. $\frac{3\mu_0 \mathrm{I}}{8\mathrm{R}}$ in downward direction

D. $\frac{3\mu_0 \mathrm{I}}{8\mathrm{R}}$ in upward direction

Answer: D

Solution:

Let's break down the problem step by step.

For a circular arc carrying a current I, the magnetic field at the center due to the arc subtending an angle θ (in radians) is given by:

$B = \frac{\mu_0 I \theta}{4\pi R}$.

In this problem, the arc is $\frac{3}{4}$ of the full circle. Since the full circle subtends an angle of 2π radians, the arc subtends:

$\theta = \frac{3}{4} \times 2\pi = \frac{3\pi}{2}$.

Plugging this value into the formula, we get:

$B = \frac{\mu_0 I\left(\frac{3\pi}{2}\right)}{4\pi R} = \frac{3\mu_0 I}{8R}$.

The direction of the magnetic field is determined by the right-hand rule. Since the current flows anticlockwise, if you curl the fingers of your right hand in the direction of the current, your thumb points upward (or out of the plane of the loop).

Thus, the magnitude and direction of the magnetic field at the center are:

$\frac{3\mu_0 I}{8R}$, upward.

Based on the options provided, the correct answer is:

Option D: $\frac{3\mu_0 I}{8R}$ in upward direction.

Question40

The magnetic induction along the axis of a toroidal solenoid is independent of

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Options:

A. number of turns per unit length.

B. current passing through it.

C. radius of the toroidal solenoid.

D. permeability

Answer: C

Solution:

The magnetic induction along the axis of a toroidal solenoid can be described by the formula:

$B = \mu_0 \cdot n \cdot I \quad \text{where} \quad n = \frac{N}{2\pi r}$

In this equation:

μ_0 represents the permeability of the medium.

n is the number of turns per unit length.

I is the current passing through the solenoid.

N is the total number of turns.

r is the radius of the toroidal solenoid.

From this relationship, it's evident that the magnetic induction B does not depend on the radius r of the toroidal solenoid.

Question41

Two coils P and Q each of radius R carry currents I and $\sqrt{8}$I respectively in same direction. Those coils are lying in perpendicular planes such that they have a common centre. The magnitude of the magnetic field at the common centre of the two coils is ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 I}{2R}$

B. $\frac{3\mu_0 I}{2R}$

C. $\frac{5\mu_0 I}{2R}$

D. $\frac{7\mu_0 \mathrm{I}}{2\mathrm{R}}$

Answer: B

Solution:

To determine the magnitude of the magnetic field at the common center of the two coils, we begin by considering the contributions from each coil separately.

Magnetic Field due to Coil P:

Coil P, with radius R and current I, produces a magnetic field at its center given by:

$B_P = \frac{\mu_0 I}{2R}$ ..... (i)

Magnetic Field due to Coil Q:

Coil Q, also with radius R but carrying a current of $\sqrt{8} \times I$, produces a magnetic field at its center:

$B_Q = \frac{\mu_0 \sqrt{8} I}{2R}$ .... (ii)

Resultant Magnetic Field:

Since coils P and Q lie in perpendicular planes, their magnetic fields are orthogonal to each other. Thus, the resultant magnetic field B_{net} at the common center is found using the Pythagorean theorem:

$$B_{\text{net}} = \sqrt{B_P^2 + B_Q^2}$$

Substituting the expressions from (i) and (ii):

$$B_{\text{net}} = \sqrt{\left(\frac{\mu_0 I}{2R}\right)^2 + \left(\frac{\mu_0 \sqrt{8} I}{2R}\right)^2}$$

Simplifying:

$$B_{\text{net}} = \sqrt{\left(\frac{\mu_0 I}{2R}\right)^2 + \left(\frac{2\sqrt{2}\mu_0 I}{2R}\right)^2}$$

$$= \frac{\mu_0 I}{2R}\sqrt{1+8}$$

$$= \frac{\mu_0 I}{2R} \times 3$$

$$= \frac{3\mu_0 I}{2R}$$

Thus, the magnitude of the magnetic field at the center is $\frac{3\mu_0 I}{2R}$.

Question42

Two concentric circular coils A and B having radii 20 cm and 10 cm respectively lie in the same plane. The current in coil A is 0.5 A in anticlockwise direction. The current in coil B , so that net magnetic field at the common centre is zero, is

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Options:

A. 0.5 A in anticlockwise direction.

B. 0.25 A in anticlockwise direction.

C. 0.25 A in clockwise direction.

D. 0.125 A in clockwise direction.

Answer: C

Solution:

To find the current in coil B that makes the net magnetic field at the common center of the coils zero, we need to express the magnetic field due to each coil at the common center and set them equal with opposite directions.

The magnetic field at the center of a circular coil due to a current I is given by:

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

where μ_0 is the permeability of free space, I is the current, and R is the radius of the coil.

For coil A (radius $R_A = 20\,\text{cm} = 0.2\,\text{m}$, current $I_A = 0.5\,\text{A}$):

$B_A = \frac{\mu_0 \cdot 0.5}{2 \cdot 0.2} = \frac{0.5\mu_0}{0.4} = \frac{\mu_0}{0.8}$

For coil B (radius $R_B = 10\,\text{cm} = 0.1\,\text{m}$, current I_B to be determined):

$B_B = \frac{\mu_0 I_B}{2 \cdot 0.1} = \frac{\mu_0 I_B}{0.2}$

To make the net magnetic field at the center zero, the magnetic fields must be equal in magnitude and opposite in direction:

$B_A = B_B$

Substituting the expressions for B_A and B_B:

$\frac{\mu_0}{0.8} = \frac{\mu_0 I_B}{0.2}$

Canceling μ_0 and multiplying through by 0.2:

$\frac{0.2}{0.8} = I_B$

Simplifying:

$I_B = 0.25\,\text{A}$

Since the magnetic fields must cancel each other and B_A is anticlockwise, B_B must be clockwise. Therefore, the current in coil B necessary for the net magnetic field at the center to be zero is:

Option C: 0.25 A in clockwise direction.

Question43

An electron is revolving in a circular orbit of radius r in a hydrogen atom. The angular momentum of the electron is L . The relation between dipole moment (m) associated with it, gyromagnetic ratio (R) and L is

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Options:

A. $\mathrm{m}=-\frac{\mathrm{L}}{\mathrm{R}}$

B. $\mathrm{m}=-\mathrm{RL}$

C. $\mathrm{m}=-\mathrm{RL}^2$

D. $\mathrm{m}=\frac{\mathrm{R}}{\mathrm{L}}$

Answer: B

Solution:

The dipole moment (m) associated with a charged particle moving in a circular orbit can be derived by considering the magnetic moment produced by the current loop. An electron with charge e revolving around the nucleus in a circular orbit of radius r with angular velocity ω constitutes a current I. The dipole moment m is given by:

$m=I \cdot A$

where $A=\pi r^2$ is the area of the loop. The current I can be expressed as the charge passing a point per unit time:

$I=\frac{e}{T}$

Here T is the period of revolution, related to angular velocity by $T=\frac{2 \pi}{\omega}$, thus:

$I=\frac{e \omega}{2 \pi}$

The angular momentum L of the electron is given by:

$L=m_e r^2 \omega$

where m_e is the mass of the electron. Substituting for ω in terms of L, we rearrange:

$\omega=\frac{L}{m_e r^2}$

Substitute ω back into the expression for m:

$m = \frac{e\omega}{2\pi} \cdot \pi r^2 = \frac{eL}{2m_e}$

The gyromagnetic ratio R is defined as the ratio of the magnetic moment to the angular momentum:

$R = \frac{m}{L} = \frac{e}{2m_e}$

Thus, the dipole moment m can be expressed in terms of L and the gyromagnetic ratio R:

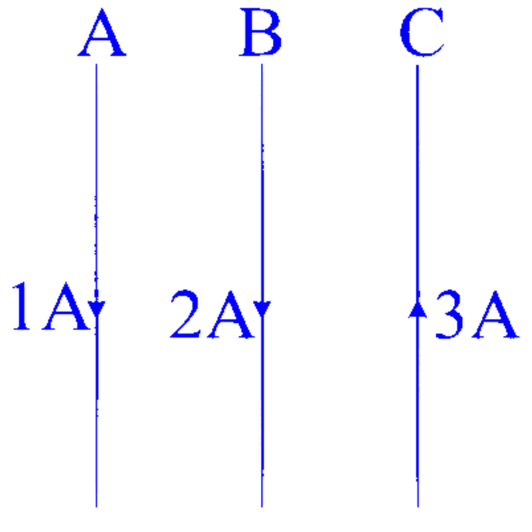
$m = -RL$

Hence, the correct relation is given by Option B:

$\mathrm{m} = -\mathrm{RL}$

Question44

Three infinite straight wires A, B and C carry currents as shown in figure. The resultant force on wire B is directed



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Options:

A. towards A

B. towards C

C. perpendicular to the plane of page

D. upwards

Answer: A

Solution:

The magnetic force experienced by a current-carrying wire in a magnetic field is given by:

$F = BIL$

The magnetic field due to wire A, which has current I and is a distance d away, is:

$B_A = \frac{\mu_0 I}{2\pi d} = \frac{\mu_0}{2\pi d}$

The force on wire B due to the magnetic field from wire A is:

$F_{AB} = \frac{\mu_0}{2\pi d} \times I \times L$

The magnetic field due to wire C, carrying a current of $3I$, is:

$B_C = \frac{\mu_0 \times 3I}{2\pi d} = \frac{3\mu_0}{2\pi d}$

The force on wire B due to the magnetic field from wire C is:

$F_{CB} = \frac{3\mu_0}{2\pi d} \times I \times L$

Given that:

$F_{CB} > F_{AB}$

It follows that the resultant force on wire B is directed towards wire A.

Question45

Two parallel wires separated by distance 'b' are carrying equal current ' I ' in the same direction. The force per unit length of the wire is

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Options:

A. $\frac{\mu_0}{4\pi}\left(\frac{I}{b^2}\right)$

B. $\frac{\mu_0}{4\pi}\left(\frac{\mathrm{I}^2}{\mathrm{b}^2}\right)$

C. $\frac{\mu_0}{4\pi}\left(\frac{\mathrm{I}^2}{b}\right)$

D. $\frac{\mu_0}{4\pi}\left(\frac{2I^2}{b}\right)$

Answer: D

Solution:

The magnetic field produced by a long, straight wire carrying a current I at a distance b from it is given by:

$B=\frac{\mu_0 I}{2\pi b}$

The force per unit length $\left(\frac{F}{L}\right)$ on a second wire carrying the same current I in this magnetic field is:

$\frac{F}{L}=I\cdot B$

Substituting the expression for B:

$\frac{F}{L}=I\cdot\frac{\mu_0 I}{2\pi b}=\frac{\mu_0 I^2}{2\pi b}$

This result can be rewritten as:

$\frac{F}{L}=\frac{\mu_0}{4\pi}\left(\frac{2I^2}{b}\right)$

Comparing with the provided options, we see that this matches Option D.

Thus, the correct answer is Option D.

Question46

Magnetic induction produced at the centre of a circular loop of radius ' R ' carrying a current is ' B '. The magnetic moment of the loop is ($\mu_0=$ permeability of free space)

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Options:

A. $\frac{\mathrm{BR}^3}{2\pi\mu_0}$

B. $\frac{2\pi\mathrm{BR}^3}{\mu_0}$

C. $\frac{\mathrm{BR}^2}{2\pi\mu_0}$

D. $\frac{2\pi\mathrm{BR}^2}{\mu_0}$

Answer: B

Solution:

The magnetic moment (m) of a circular loop carrying current can be calculated using the formula:

$m = n \cdot I \cdot A$

where:

n is the number of turns in the loop,

I is the current,

A is the area of the loop.

For a circular loop, the magnetic induction B at the center of the loop is given by:

$B = \frac{\mu_0 \cdot n \cdot I}{2R}$

where:

μ_0 is the permeability of free space,

R is the radius of the loop.

We can rearrange the formula for I:

$I = \frac{B \cdot 2R}{\mu_0 \cdot n}$

For a single loop $(n = 1)$, the area A is:

$A = \pi R^2$

Substitute the expression for I and A back into the formula for the magnetic moment:

$m = \frac{B \cdot 2R}{\mu_0} \times \pi R^2$

Simplifying this expression, we find:

$m = \frac{2\pi BR^3}{\mu_0}$

Question47

The strength of magnetic field at a perpendicular distance ' x ' near a long straight conductor carrying current ' I ' is ' B '. The magnetic field at a distance $\frac{x}{3}$ from straight conductor will be

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Options:

A. $\frac{\mathrm{B}}{3}$

B. 3 B

C. $\frac{\mathrm{B}^2}{9}$

D. 9 B^2

Answer: B

Solution:

To determine the strength of the magnetic field at a distance of $\frac{x}{3}$ from a long straight conductor carrying a current I, we start with the formula that relates the magnetic field B to the distance r from the conductor:

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

Given that the initial magnetic field strength B is at a distance x, we can compare it with the new magnetic field strength B_2 at the reduced distance $\frac{x}{3}$:

$\frac{B}{B_2} = \frac{r_2}{r_1}$

Substituting the distances, we have:

$\frac{B}{B_2} = \frac{\frac{x}{3}}{x}$

Simplifying the fraction on the right:

$\frac{B}{B_2} = \frac{1}{3}$

From this relationship, we can solve for B_2:

$B_2 = 3B$

Thus, the magnetic field at a distance $\frac{x}{3}$ from the conductor is $3B$.

Question48

An infinitely long straight conductor carrying current 'I' is bent in a shape as shown in figure. The radius of the circular part of loop is 'r'. The magnetic induction at the centre 'C' is (μ = permeability of free space)

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Options:

A. Zero

B. $\frac{\mu_0}{4\pi}\frac{2I}{r}(1+\pi)$

C. $\frac{\mu_0}{4\pi}\frac{\mathrm{I}}{\mathrm{r}}(1+\pi)$

D. $\frac{\mu_0}{4\pi}\frac{2I}{r}(\pi-1)$

Answer: B

Solution:

Here, net field,

B = Field due to semi-circular portion + Field due to semi-infinite straight conductor

$= \left(\frac{\mu_0 I}{4r}+\frac{\mu_0 I}{4\pi r}\right) = \frac{\mu_0 I}{4r}\left(1+\frac{1}{\pi}\right) = \frac{\mu_0 I(\pi+1)}{4\pi r}$

Field due to semi-circular portion as well semi-infinite straight conductor is directed outwards and perpendicular to the plane of paper. Thus net field is directed out of the plane of the paper.

Question49

A current carrying circular loop of radius ' R ' and current carrying long straight wire are placed in the same plane. The current through circular loop and long straight wire are ' I_c ' and ' $\mathrm{I_w}$ ' respectively. The perpendicular distance between centre of the circular loop and wire is ' d '. The magnetic field at the centre of the loop will be zero when separation ' d ' is equal to

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Options:

A. $\frac{\mathrm{RI_w}}{\pi \mathrm{I_c}}$

B. $\frac{\mathrm{RI_c}}{\pi \mathrm{I_w}}$

C. $\frac{\pi \mathrm{I_c}}{\mathrm{RI_w}}$

D. $\frac{\pi \mathrm{I_w}}{\mathrm{RI_c}}$

Answer: A

Solution:

To determine when the magnetic field at the center of the circular loop is zero, consider the superposition of magnetic fields from both the circular loop and the long straight wire.

Magnetic Field due to the Circular Loop:

The magnetic field at the center of a circular loop carrying current I_c is given by:

$$B_{\text{loop}} = \frac{\mu_0 I_c}{2R}$$

where μ_0 is the permeability of free space and R is the radius of the loop.

Magnetic Field due to the Long Straight Wire:

The magnetic field due to a long straight wire at a perpendicular distance d is given by:

$B_{\text{wire}} = \frac{\mu_0 I_w}{2\pi d}$

where I_w is the current in the wire.

Condition for Zero Magnetic Field at the Center of the Loop:

For the magnetic field at the center to be zero, the magnitudes of the magnetic fields from the loop and the wire must be equal, i.e.,

$B_{\text{loop}} = B_{\text{wire}}$

Substituting the expressions for B_{loop} and B_{wire} :

$\frac{\mu_0 I_c}{2R} = \frac{\mu_0 I_w}{2\pi d}$

Canceling μ_0 from both sides and solving for d:

$\frac{I_c}{2R} = \frac{I_w}{2\pi d}$

Rearrange to solve for d:

$d = \frac{R I_w}{\pi I_c}$

Hence, the correct option is **Option A**:

$d = \frac{\mathrm{RI_w}}{\pi \mathrm{I_c}}$

Question50

Magnetic field at the centre of a circular loop of area ' A ' is ' B '. The magnetic moment of the loop will be

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Options:

A. $\frac{\mathrm{BA}^2}{\mu_0 \pi}$

B. $\frac{2\mathrm{BA}^{3/2}}{\mu_0 \pi}$

C. $\frac{\mathrm{BA}^{1/2}}{\mu_0 \pi^{1/2}}$

D. $\frac{2\mathrm{BA}^{3/2}}{\mu_0 \pi^{1/2}}$

Answer: D

Solution:

⭐ Step 1: Express radius in terms of area

$$A = \pi R^2$$

$$R = \sqrt{\frac{A}{\pi}}$$

⭐ Step 2: Use magnetic field formula

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

Substitute R:

$$B = \frac{\mu_0 I}{2\sqrt{A/\pi}}$$

Rearrange to find current I:

$$I = \frac{2B\sqrt{A/\pi}}{\mu_0}$$

⭐ Step 3: Magnetic moment $M = IA$

$$M = A \cdot \frac{2B\sqrt{A/\pi}}{\mu_0}$$

Combine:

$$M = \frac{2BA^{3/2}}{\mu_0 \pi^{1/2}}$$

⭐ Final Expression:

$$\boxed{M = \frac{2BA^{3/2}}{\mu_0 \pi^{1/2}}}$$

Question51

A boat is moving due east in a region where the earth's magnetic field is 3.6×10^{-5} N/Am due north and horizontal. The boat carries

a vertical conducting rod 2 m long. If the speed of the boat is $2.00 \mathrm{~m/s}$, the magnitude of the induced e.m.f. in the rod is

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Options:

A. 1.4 mV

B. 0.72 mV

C. 0.54 mV

D. 0.144 mV

Answer: D

Solution:

We can find the induced e.m.f. using the formula for motional e.m.f.:

$\epsilon = B L v \sin \theta$

where

$B = 3.6 \times 10^{-5}$ T is the Earth's magnetic field.

$L = 2$ m is the length of the rod.

$v = 2.00$ m/s is the speed of the boat.

θ is the angle between the velocity of the rod and the magnetic field.

In this problem:

The boat is moving due east.

The Earth's magnetic field is due north.

Because the velocity (east) and the magnetic field (north) are perpendicular, the angle is $\theta = 90^{\circ}$ and $\sin 90^{\circ} = 1$.

Plugging in the values:

$\epsilon = (3.6 \times 10^{-5} \text{ T})(2 \text{ m})(2.00 \text{ m/s})(1)$

$\epsilon = (3.6 \times 10^{-5})(4) \text{ V}$

$\epsilon = 1.44 \times 10^{-4} \text{ V}$

To convert this into millivolts (mV):

1.44×10^{-4} V $= 0.144$ mV

Thus, the magnitude of the induced e.m.f. in the rod is 0.144 mV, which corresponds to Option D.

Question52

The magnetic flux near the axis and inside the air core solenoid of length 80 cm carrying current ' I ' is 1.57×10^{-6} Wb. Its magnetic moment will be [cross-sectional area of a solenoid is very small as compared to its length, $\mu_0 = 4\pi \times 10^{-7}$ SI unit $](\pi = 3.14)$

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Options:

A. $0.25 \mathrm{~Am}^2$

B. $0.50 \mathrm{~Am}^2$

C. $1 \mathrm{~Am}^2$

D. $1.2 \mathrm{~Am}^2$

Answer: C

Solution:

The magnetic induction inside an air-core solenoid is given by the formula:

$B = \frac{\mu_0 N I}{L}$

where:

μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ SI unit),

N is the number of turns,

I is the current,

L is the length of the solenoid.

The magnetic flux (ϕ) within the solenoid is expressed as:

$\phi = BA = \frac{\mu_0 N I A}{L}$

where A is the cross-sectional area of the solenoid.

We are tasked with finding the magnetic moment, which can be derived from:

Magnetic moment $= NIA = \frac{\phi L}{\mu_0}$

Substituting the given values, we solve for the magnetic moment:

Magnetic moment $= \frac{(1.57 \times 10^{-6} \text{ Wb }) \times 0.8 \text{ m}}{4\pi \times 10^{-7} \text{ SI unit}}$

Magnetic moment $= 1 \text{ Am}^2$

Thus, the magnetic moment of the solenoid is 1 Am^2.

Question53

Two long straight parallel wires are separated by a distance '2d'. Each wire carries a current 'I' in the same direction. The magnetic field at a point 'P' midway between them is

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Options:

A. $\frac{2\mu_0 I}{r}$

B. zero

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

D. $\frac{\mu_0 I}{2r}$

Answer: B

Solution:

Two long straight wires are parallel and separated by a distance of $2d$.

Point P is exactly halfway between them, so the distance from each wire to P is d.

The magnetic field due to a long straight current-carrying wire at a distance r is given by

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

Thus, at P, the magnitude of the field from each wire is

$\frac{\mu_0 I}{2\pi d}$.

However, the direction of the magnetic field is determined by the right-hand rule.

For the left wire (located at $x = -d$), with current upward, at point P (to its right), the magnetic field points into the page.

For the right wire (located at $x = d$), with current upward, at point P (to its left), the magnetic field points out of the page.

Since the two fields have equal magnitude but opposite directions, they cancel each other out.

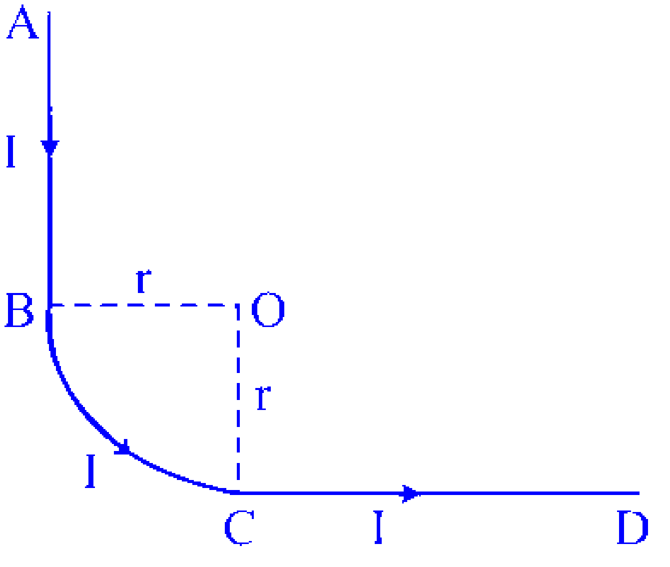
Thus, the net magnetic field at point P is **zero**.

Final Answer: Option B

Zero

Question54

The magnitude of magnetic field at point 'O' in the following figure will be



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Options:

A. $\frac{\mu_0}{4\pi} \frac{\mathrm{I}}{\mathrm{r}}\left(\frac{2}{\pi}+2\right)$

B. $\frac{\mu_0}{4\pi} \frac{\mathrm{I}}{\mathrm{r}}\left(\frac{2}{\pi}-2\right)$

C. $\frac{\mu_0}{4\pi} \frac{\mathrm{I}}{\mathrm{r}}\left(2+\frac{\pi}{2}\right)$

D. $\frac{\mu_0}{4\pi} \frac{\mathrm{I}}{\mathrm{r}}\left(2-\frac{\pi}{2}\right)$

Answer: C

Solution:

Magnetic field due to current carrying arc is,

$B=\frac{\mu_0 I}{4\pi \mathrm{r}} \times \theta=\frac{\mu_0 \mathrm{I}}{4\pi \mathrm{r}} \times \frac{\pi}{2}=\frac{\mu_0 \mathrm{I}}{8 \mathrm{r}}$

Magnetic field due to semi-infinite current carrying straight wires AB and CD is,

$\frac{2\mu_0 I}{4\pi \mathrm{r}}=\frac{\mu_0 I}{2\pi \mathrm{r}}$

$\therefore$ Total magnetic field at 'O' will be,

$$\begin{aligned}
\frac{\mu_0 \mathrm{I}}{2\pi \mathrm{r}}+\frac{\mu_0 \mathrm{I}}{8 \mathrm{r}} & =\frac{\mu_0 \mathrm{I}}{2 \mathrm{r}}\left(\frac{1}{\pi}+\frac{1}{4}\right) \\
& =\frac{\mu_0}{4\pi} \frac{1}{\mathrm{r}}\left(\frac{2\pi}{\pi}+\frac{2\pi}{4}\right) \\
& =\frac{\mu_0}{4\pi} \frac{1}{r}\left(2+\frac{\pi}{2}\right)
\end{aligned}$$

Question55

A coil of ' n ' turns and radius ' R ' carries a current 'I'. It is unwound and rewound to make a new coil of radius $\frac{R}{3}$ and the same current is passed through it. The ratio of the magnetic moment of the new coil to that of the original coil is

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Options:

A. 3

B. 2

C. $\frac{1}{3}$

D. $\frac{1}{2}$

Answer: C

Solution:

To determine the ratio of the magnetic moment of the new coil to that of the original coil, we start with the expression for the magnetic moment. The initial magnetic moment is given by:

$\mu_1 = n_1 I \pi R_1^2$

where n_1 is the number of turns, I is the current, and R_1 is the radius of the original coil. For the initial condition, we have $R_1 = R$.

For the new coil, the magnetic moment is:

$\mu_2 = n_2 I \pi R_2^2$

where n_2 is the number of turns in the new coil, $R_2 = \frac{R}{3}$, and the same current I is used.

Since the coil is rewound using the same wire, the product of the number of turns and the length of each turn remains the same. This implies:

$n_1 \times 2\pi R_1 = n_2 \times 2\pi R_2$

Simplifying gives:

$n_2 = \frac{R_1}{R_2} n_1 = 3n_1$

We now calculate the ratio of the magnetic moments:

$\frac{\mu_2}{\mu_1} = \frac{n_2 I \pi R_2^2}{n_1 I \pi R_1^2}$

Substitute for n_2 and R_2:

$\frac{\mu_2}{\mu_1} = \frac{3n_1 I \pi \left(\frac{R}{3}\right)^2}{n_1 I \pi R^2}$

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

$= \frac{1}{3}$

The ratio of the magnetic moment of the new coil to that of the original coil is $\frac{1}{3}$.

Question56

A charged particle is moving in a uniform magnetic field in a circular path of radius ' R '. When the kinetic energy of the particle is increased to three times, then the new radius will be

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Options:

A. $\frac{\mathrm{R}}{3}$

B. $\frac{\mathrm{R}}{\sqrt{3}}$

C. $\sqrt{3} \cdot \mathrm{R}$

D. $3 \cdot \mathrm{R}$

Answer: C

Solution:

The radius of a charged particle moving in a uniform magnetic field is given by:

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

From this equation, we see that the radius r is proportional to the square root of the kinetic energy K, i.e., $r \propto \sqrt{K}$.

Given that the kinetic energy of the particle increases to three times its initial value, the new kinetic energy K_2 is $3K$.

Using the proportionality relation:

$\frac{R}{R_2} = \sqrt{\frac{K}{3K}}$

Simplifying the equation:

$R_2 = \sqrt{3} \cdot R$

Thus, when the kinetic energy is tripled, the new radius of the particle's path will be $\sqrt{3} \times R$.

Question57

A circular arc of radius r carrying current ' I ' subtends an angle $\frac{\pi}{8}$ at its entre. The radius of a metal wire is uniform. The magnetic induction at the centre of circular arc is ($\mu_0 =$ permeability of free space)

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Options:

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

B. $\frac{\mu_0 I}{32 r}$

C. $\frac{\mu_0 I}{64 r}$

D. $\frac{\mu_0 I}{16 r}$

Answer: B

Solution:

The magnetic induction at the center of a circular arc can be determined using the formula:

$B = \frac{\mu_0 I}{4 \pi r} \times \theta$

Given that the angle θ subtended by the arc is $\frac{\pi}{8}$, we substitute θ in the formula:

$B = \frac{\mu_0 I}{4 \pi r} \times \frac{\pi}{8}$

Simplifying this expression gives:

$B = \frac{\mu_0 I}{32 r}$

Question58

Electron of mass ' m ' and charge ' q ' is travelling with speed ' v ' along a circular path of radius ' R ' at right angles to a uniform magnetic field of intensity ' B '. If the speed of the electron is halved and the magnetic field is doubled, the resulting path would have radius

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Options:

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

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

C. 2R

D. 4R

Answer: B

Solution:

✔ Step-by-Step Conceptual Solution

The radius R of the circular path of a charged particle moving perpendicular to a magnetic field is:

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

So,

$$R \propto \frac{v}{B}$$

✔ Given Changes

- Speed is **halved:**

$$v' = \frac{v}{2}$$

- Magnetic field is **doubled:**

$$B' = 2B$$

✔ New Radius

$$R' = \frac{mv'}{qB'}$$

Substitute the new values:

$$R' = \frac{m(v/2)}{q(2B)}$$

$$R' = \frac{mv}{qB} \cdot \frac{1}{4}$$

$$R' = \frac{R}{4}$$

⭐ Final Answer: $\boxed{\frac{R}{4}}$

Question59

A current carrying circular loop of radius ' R ' and current carrying long straight wire are placed in the same plane. I_c and I_w are the currents through circular loop and long straight wire respectively. The perpendicular distance between centre of the circular loop and wire is ' d '. The magnetic field at the centre of the loop will be zero when separation ' d ' is equal to

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Options:

A. $\frac{\mathrm{RI}_w}{\pi \mathrm{I}_\mathrm{c}}$

B. $\frac{\mathrm{RI}_\mathrm{c}}{\pi \mathrm{I}_\mathrm{w}}$

C. $\frac{\pi \mathrm{I}_\mathrm{c}}{R\mathrm{I}_\mathrm{w}}$

D. $\frac{\pi \mathrm{I}_\mathrm{w}}{\mathrm{R}_\mathrm{c}}$

Answer: A

Solution:

To find when the magnetic field at the center of the circular loop is zero, we need to set the magnetic field produced by the circular loop equal in magnitude and opposite in direction to the magnetic field produced by the long straight wire.

The magnetic field at the center of a current-carrying circular loop is given by:

$B_{\text{loop}} = \frac{\mu_0 I_c}{2R}$

where I_c is the current in the loop, R is the radius of the loop, and μ_0 is the permeability of free space.

The magnetic field at a perpendicular distance d from a long straight current-carrying wire is:

$B_{\text{wire}} = \frac{\mu_0 I_w}{2\pi d}$

where I_w is the current in the wire and d is the distance from the wire to the point of interest.

For the magnetic field at the center of the loop to be zero, these fields must be equal in magnitude:

$\frac{\mu_0 I_c}{2R} = \frac{\mu_0 I_w}{2\pi d}$

Canceling μ_0 and simplifying, we get:

$\frac{I_c}{R} = \frac{I_w}{\pi d}$

Solving for d:

$d = \frac{\pi R I_w}{I_c}$

Therefore, the separation d that makes the magnetic field at the center of the loop zero is given by:

Option A: $\frac{\mathrm{RI}_w}{\pi \mathrm{I_c}}$

Question60

A long solenoid carrying a current produces magnetic field B along its axis. If the number of turns per cm are tripled and the current is made $\left(\frac{1}{4}\right)^{\text{th}}$ then the new value of magnetic field will be

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Options:

A. $\frac{B}{3}$

B. $\frac{\mathrm{B}}{4}$

C. $\frac{3B}{4}$

D. $\frac{2\ \mathrm{B}}{3}$

Answer: C

Solution:

The magnetic field inside a long solenoid is given by the formula:

$B=\mu_0 n I$

where:

B is the magnetic field,

μ_0 is the permeability of free space,

n is the number of turns per unit length,

I is the current passing through the solenoid.

Initially, we have the magnetic field B given by:

$B=\mu_0 n I$

Now, the number of turns per unit length n is tripled, so the new turns per unit length is $3n$. The current I is reduced to $\frac{1}{4} I$. The new magnetic field B_{new} is:

$B_{\text{new}}=\mu_0(3 n)\left(\frac{1}{4} I\right)$

Simplifying this expression gives:

$B_{\text{new}}=\mu_0 \cdot 3 n \cdot \frac{1}{4} I=\frac{3}{4}\left(\mu_0 n I\right)$

Thus, the new magnetic field B_{new} is:

$B_{\text{new}}=\frac{3}{4} B$

Therefore, the correct answer is:

Option C: $\frac{3 B}{4}$

Question61

The magnetic potential energy stored in certain inductor is 64×10^{-3} J, when the current in the inductor is 80 mA . This inductor is of inductance

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Options:

A. 0.20 H

B. 2.0 H

C. 20 H

D. 200 H

Answer: C

Solution:

The magnetic potential energy stored in an inductor is given by the formula:

$E = \frac{1}{2} L I^2$

where E is the energy stored in the inductor, L is the inductance, and I is the current through the inductor.

Here, the given energy E is 64×10^{-3} J, and the current I is $80\,\text{mA} = 80 \times 10^{-3}$ A.

To find the inductance L, rearrange the formula to solve for L:

$L = \frac{2E}{I^2}$

Substitute the values into the equation:

$L = \frac{2 \times 64 \times 10^{-3}}{(80 \times 10^{-3})^2}$

Calculating this gives:

$L = \frac{128 \times 10^{-3}}{6400 \times 10^{-6}} = 20\,\text{H}$

Therefore, the inductance of the inductor is $20\,\text{H}$.

Question62

The magnetic induction due to an ideal solenoid is independent of

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Options:

A. total number of turns of the wire.

B. length of the solenoid.

C. radius of the wire.

D. current carried by the wire.

Answer: C

Solution:

For an **ideal solenoid** (long, tightly wound), the magnetic field inside is given (in SI units) by

$B = \mu_0 n I = \mu_0 \left(\frac{N}{L}\right) I,$

where

μ_0 is the permeability of free space,

$n = \frac{N}{L}$ is the number of turns per unit length,

N is the total number of turns,

L is the length of the solenoid, and

I is the current in the winding.

From this formula, we see that B **does** depend on:

the total number of turns N (through n),

the length L (also through n),

the current I.

However, in an **ideal** solenoid model, the **radius (thickness) of the wire** that makes up the solenoid winding does **not** appear in the expression for B. Thus, among the given options, the magnetic induction (field) inside an ideal solenoid is **independent** of:

(C) the radius of the wire.

Question63

The magnetic field intensity inside current carrying solenoid is $\mathrm{H} = 2.4 \times 10^3\ \mathrm{A/m}$. If length and number of turns of a solenoid is

15 cm and 60 turns respectively. The current flowing in the solenoid is

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Options:

A. 4 A

B. 6 A

C. 0.6 A

D. 60 A

Answer: B

Solution:

The magnetic field intensity inside a solenoid can be given by the formula:

$H = \frac{n \cdot I}{L}$

where:

H is the magnetic field intensity,

n is the number of turns,

I is the current,

L is the length of the solenoid in meters.

Given values:

$H = 2.4 \times 10^3 \text{ A/m}$

$n = 60$

$L = 15 \text{ cm} = 0.15 \text{ m}$

To find the current I, rearrange the formula to solve for I:

$I = \frac{H \cdot L}{n}$

Substitute in the given values:

$I = \frac{2.4 \times 10^3 \text{ A/m} \times 0.15 \text{ m}}{60}$

Calculate:

$I = \frac{360}{60}$ A

$I = 6$ A

Therefore, the current flowing in the solenoid is 6 A.

Correct Option:

Option B - 6 A

Question64

A particle carrying a charge equal to 100 times the charge on an electron is rotating one rotation per second in a circular path of radius 0.8 m . The value of magnetic field produced at the centre will be (μ_0 = permeability of vacuum)

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Options:

A. $\frac{10^{-7}}{\mu_0}$

B. $10^{-17} \mu_0$

C. $10^{-6} \mu_0$

D. $10^{-7} \mu_0$

Answer: B

Solution:

Charged particle moving in a circular path acts like a current carrying coil.

Let I be the current due to the particle current is,

$I = \frac{q}{t} = \frac{100 \times e}{1} = 100\text{e}$

Magnetic field at the centre due to current carrying coil,

$$B_{\text{centre}} = \frac{\mu_0}{4\pi}\frac{2\pi I}{r} = \frac{\mu_0}{4\pi}\frac{2\pi \times 100e}{r}$$
$$= \frac{\mu_0}{4}\frac{2 \times 100\left(1.6 \times 10^{-19}\right)}{0.8} = 10^{-17}\mu_0$$

Question65

A charged particle of charge ' q ' is accelerated by a potential difference ' V ' enters a region of uniform magnetic field ' B ' at right angles to the direction of field. The charged particle completes semicircle of radius ' r ' inside magnetic field. The mass of the charged particle is

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Options:

A. $\frac{r^2 qB^2}{2\text{ V}}$

B. $\frac{r^2q^2B^2}{\sqrt{2}V}$

C. $\frac{qrB}{2\text{ V}}$

D. $\frac{q^2r^2\text{ B}^2}{\text{V}}$

Answer: A

Solution:

When charged particle enters perpendicular to a uniform magnetic field, then it follows a circular path.

Its radius is given by,

$R = \frac{mv}{qB} = \frac{\sqrt{2mE}}{qB}$ .... (i)

As the charged particle is accelerated through potential difference of V,

$\text{K.E} = \text{qV}$

Substituting in (i),

$$R=\frac{\sqrt{2mqV}}{qB}=\sqrt{\frac{2mV}{q}}\times\frac{1}{B}$$

$$\therefore\quad R^2=\frac{2mV}{q}\times\frac{1}{B^2}$$

$$\therefore\quad m=\frac{R^2qB^2}{2V}=\frac{r^2qB^2}{2V}\quad \text{.... (given, R = r)}$$

Question66

A charged particle is moving in a uniform magnetic field in a circular path with radius ' R '. When the energy of the particle is doubled, then the new radius will be

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Options:

A. $\frac{\mathrm{R}}{\sqrt{2}}$

B. $2R$

C. $\frac{\mathrm{R}}{2}$

D. $\sqrt{2}R$

Answer: D

Solution:

When a charged particle moves in a uniform magnetic field, it experiences a force that causes it to move in a circular path. The radius of this path is given by:

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

where:

m is the mass of the particle,

v is the speed of the particle,

q is the charge,

B is the magnetic field strength.

The kinetic energy of the particle is:

$K = \frac{1}{2} m v^2$

If the energy is doubled, then:

$K' = 2K = \frac{1}{2} m v'^2$

Solving for the new speed v':

Equate the energies:

$\frac{1}{2} m v'^2 = 2\left(\frac{1}{2} m v^2\right)$

Simplify:

$v'^2 = 2v^2$

Take the square root:

$v' = \sqrt{2}\, v$

Now substitute v' back into the radius formula:

$R' = \frac{mv'}{qB} = \frac{m(\sqrt{2} v)}{qB} = \sqrt{2}\left(\frac{mv}{qB}\right) = \sqrt{2}\, R$

So, when the energy of the particle is doubled, the new radius is:

$\boxed{\sqrt{2}\, R}$

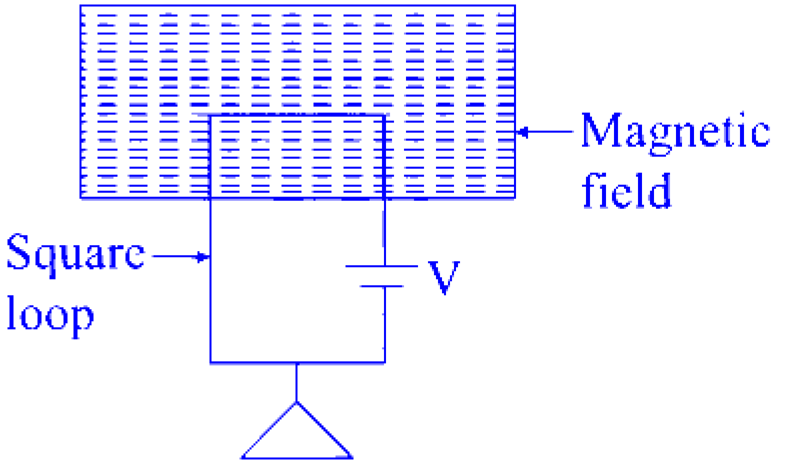
Thus, the correct option is:

Option D: $\sqrt{2}\, R$

Question67

A massless square loop of wire of resistance ' R ' supporting a mass ' M ' hangs vertically with one of its sides in a uniform magnetic field

' B ' directed outwards in the shaded region. A d.c. voltage ' V ' is applied to the loop. For what value of ' V ' the magnetic force will exactly balance the weight of the supporting mass ' M '? (side of loop = L, g $=$ acceleration due to gravity)



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Options:

A. $\frac{\mathrm{Mg}}{\mathrm{LBR}}$

B. $\frac{\mathrm{LB}}{\mathrm{MgR}}$

C. $\frac{\mathrm{MgR}}{\mathrm{LB}}$

D. $\frac{\mathrm{LR}}{\mathrm{MgB}}$

Answer: C

Solution:

To determine the voltage V needed so that the magnetic force exactly balances the weight of the mass M supported by the loop, we start with the following condition for balance:

$F = Mg$

where F is the magnetic force, M is the mass, and g is the acceleration due to gravity.

Given that the magnetic force F on a current-carrying wire in a magnetic field is calculated by:

$BIL = Mg$

where:

B is the magnetic field,

I is the current through the wire,

L is the length of the side of the square loop,

Mg is the gravitational force or weight of the mass.

According to Ohm's Law:

$V = IR$

where:

V is the applied voltage,

I is the current,

R is the resistance of the wire.

Substituting for I from Ohm's Law:

$BI \cdot L = Mg$

$B\left(\frac{V}{R}\right)L = Mg$

To find V, rearrange the equation:

$V = \frac{MgR}{BL}$

Thus, the voltage V required is:

$V = \frac{MgR}{BL}$

Question68

A thin ring of radius ' R ' carries a uniformly distributed charge. The ring rotates at constant speed ' N ' r.p.s. about its axis perpendicular to the plane. If ' B ' is the magnetic field at the centre, the charge on the ring is ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 \text{ N}}{2\text{RB}}$

B. $\frac{RB}{2\mu_0 \text{ N}}$

C. $\frac{\mu_0 N}{RB}$

D. $\frac{2RB}{\mu_0 \text{ N}}$

Answer: D

Solution:

The magnetic field at the center of a rotating charged ring can be derived using the concept of a current loop. The magnetic field due to a circular loop of current I at its center is given by:

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

where μ_0 is the permeability of free space and R is the radius of the loop.

In this scenario, the ring is carrying a charge Q and is rotating at N revolutions per second (r.p.s.). The equivalent current I due to this rotation can be calculated using the relation:

$I = QN$

since in one full rotation, all the charge completes a full cycle, effectively forming a current loop.

Substitute $I = QN$ into the equation for the magnetic field:

$B = \frac{\mu_0 QN}{2R}$

Rearranging for the charge Q:

$Q = \frac{2RB}{\mu_0 N}$

Thus, the charge on the ring is given by option D:

$\frac{2RB}{\mu_0 \text{ N}}$

Question69

A charged particle is moving along a magnetic field line. What is the magnetic force acting on the particle? $\left(\sin 0^\circ = 0, \sin \frac{\pi}{2} = 1\right)$

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Options:

A. Opposite to its velocity.

B. Perpendicular to its velocity.

C. Zero.

D. Along its velocity.

Answer: C

Solution:

The magnetic force acting on a charged particle moving through a magnetic field is given by the expression:

$\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$

where:

$\mathbf{F}$ is the magnetic force,

q is the charge of the particle,

$\mathbf{v}$ is the velocity vector of the particle,

$\mathbf{B}$ is the magnetic field vector,

$\times$ denotes the cross product.

When a charged particle moves along a magnetic field line, the velocity of the particle ($\mathbf{v}$) is parallel to the magnetic field ($\mathbf{B}$). In this scenario, the angle θ between the velocity vector and the magnetic field vector is 0°. Therefore, the magnitude of the magnetic force can be computed as:

$F = qvB \sin \theta = qvB \sin 0^\circ = qvB \times 0 = 0$

Thus, the magnetic force acting on the particle is zero. The correct answer is:

Option C: Zero.

Question70

A current of 5 A flows through a toroid having a core of mean radius 20 cm . If 4000 turns of the conducting wire are wound on the core, then the magnetic field inside the core of the toroid is [permeability of free space $= 4\pi \times 10^{-7}$ SI units]

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Options:

A. $8 \times 10^{-2}\ \mathrm{Wb/m^2}$

B. $6 \times 10^{-2}\ \mathrm{Wb/m^2}$

C. $5 \times 10^{-2}\ \mathrm{Wb/m^2}$

D. $2 \times 10^{-2}\ \mathrm{Wb/m^2}$

Answer: D

Solution:

The magnetic field inside a toroid can be calculated using the formula:

$B = \frac{\mu_0 \cdot N \cdot I}{2\pi r}$

where:

B is the magnetic field.

$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$ is the permeability of free space.

$N = 4000$ is the number of turns.

$I = 5\ \mathrm{A}$ is the current.

$r = 0.2\ \mathrm{m}$ is the mean radius of the toroid.

Substitute the values into the formula:

Calculate the numerator:

$\mu_0 \cdot N \cdot I = (4\pi \times 10^{-7}) \times 4000 \times 5$

Calculate the denominator:

$2\pi r = 2\pi \times 0.2$

Perform the calculations:

Numerator:

$(4\pi \times 10^{-7}) \times 4000 \times 5 = 4\pi \times 2000 \times 10^{-7} = 8\pi \times 10^{-4}$

Denominator:

$2\pi \times 0.2 = 0.4\pi$

Now, divide the numerator by the denominator:

$B = \frac{8\pi \times 10^{-4}}{0.4\pi} = \frac{8 \times 10^{-4}}{0.4} = 2 \times 10^{-3}\ \mathrm{T}$

Converting tesla to weber per square meter:

$B = 2 \times 10^{-2}\ \mathrm{Wb/m^2}$

Thus, the magnetic field inside the core of the toroid is $\boxed{2 \times 10^{-2}\ \mathrm{Wb/m^2}}$, corresponding to Option D.

Question71

A particle having a charge 50 e is revolving in a circular path of radius 0.4 m with $1 \mathrm{r.p.s.}$ The magnetic field produced at the centre of the circle is $\left(\mu_0 = 4\pi \times 10^{-7}\right.$ SI units and $e = 1.6 \times 10^{-19}$c)

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Options:

A. $10^{-7} \mu_0$

B. $10^{-10} \mu_0$

C. $10^{-14} \mu_0$

D. $10^{-17} \mu_0$

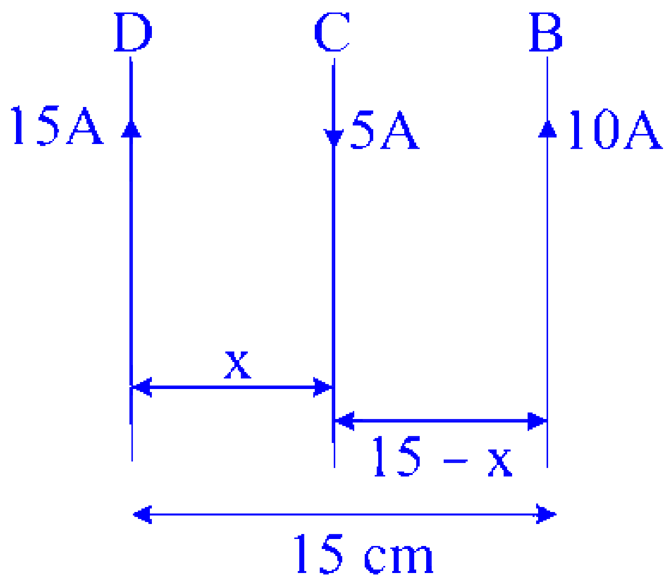
Answer: D

Solution:

$$\begin{aligned} B &= \frac{\mu_0 \mathrm{qf}}{2\mathrm{r}} = \frac{\mu_0 \times 50}{2 \times 0.4} \\ &= \frac{\mu_0 \times 50 \times 1.6 \times 10^{-9}}{0.8} \quad \ldots (\because \mathrm{f} = 1 \text{ r.p.s.}) \\ &= 10^{-17} \mu_0 \end{aligned}$$

Question72

Three long, straight parallel wires carrying currents are arranged as shown. The wire C which carries a current of 5.0 A is so placed that it experiences no force. The distance of wire C from wire D is



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Options:

A. 9 cm

B. 7 cm

C. 5 cm

D. 3 cm

Answer: A

Solution:

Wire C experiences no force.

$\therefore \quad F_{CD} = F_{CB}$

$\therefore \quad \frac{\mu_0 i_C i_D}{2\pi x} = \frac{\mu_0 i_C i_B}{2\pi(15-x)}$

$\therefore \quad \frac{5\times15}{x} = \frac{5\times10}{15-x}$

$\therefore \quad x = 9 \text{ cm}$

Question73

Cyclotron is used to

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Options:

A. accelerate neutrons.

B. accelerate positively charged particles only.

C. accelerate negatively charged particles only.

D. accelerate positively and negatively charged particles.

Answer: B

Solution:

✅ **Correct Answer: B. accelerate positively charged particles only**

✔ Why cyclotron accelerates only positive charges

A cyclotron works on the combined effect of:

- **Uniform magnetic field** → makes charged particles move in circular paths
- **Alternating electric field** → accelerates them every half rotation

For a particle in a magnetic field:

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

To be *trapped* in a circular path and accelerated, the particle must:

✔ **Move in a circular orbit**

✔ **Be pushed toward the center by magnetic force**

This works **only for positively charged particles** (protons, deuterons, α-particles).

❌ Why not electrons?

Electrons **cannot** be accelerated in a cyclotron because:

1️⃣ **They have *very small mass***

→ Their speed quickly becomes relativistic.

2 Relativistic mass increases

$$m_{\text{rel}} = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

→ Cyclotron frequency changes, so electrons fall out of phase with the accelerating electric field.

Thus **they cannot be synchronised**, making a cyclotron ineffective for electrons.

Question74

The magnetic field at the centre of a current carrying circular coil of area ' A ' is ' B '. The magnetic moment of the coil is ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{2\mu_0\pi^{1/2}}{\mathrm{BA}^{3/2}}$

B. $\frac{\mathrm{BA}^{3/2}}{\mu_0\pi}$

C. $\frac{2\ \mathrm{B}\ \mathrm{A}^{3/2}}{\mu_0\pi^{1/2}}$

D. $\frac{\mathrm{BA}^2}{\mu_0\pi}$

Answer: C

Solution:

$$\mathrm{A} = \pi\mathrm{r}^2 \Rightarrow r = \sqrt{\frac{\mathrm{A}}{\pi}}$$

$$\therefore \quad \mathrm{B}=\frac{\mu_0 \mathrm{I}}{2 \mathrm{r}}=\frac{\mu_0 \mathrm{I}}{2 \sqrt{\frac{\mathrm{A}}{\pi}}}$$

$$\therefore \quad \mathrm{I}=\frac{2 \mathrm{~B}}{\mu_0} \sqrt{\frac{\mathrm{A}}{\pi}}$$

Magnetic moment $\mathrm{m}=\mathrm{IA}$

$$\mathrm{IA}=\frac{2 \mathrm{~B}}{\mu_0} \sqrt{\frac{\mathrm{A}}{\pi}} \times \mathrm{A}=\frac{2 \mathrm{BA}^{3 / 2}}{\mu_0 \pi^{1 / 2}}$$

Question75

Two identical current carrying coils with same centre are placed with their planes perpendicular to each other. If current $\mathrm{I}=\sqrt{2}$ A and radius of the coil is $R=1$ m, then magnetic field at centre is equal to ($\mu_0=$ permeability of free space)

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Options:

A. μ_0

B. $\frac{\mu_0}{2}$

C. $2 \mu_0$

D. $\sqrt{2} \mu_0$

Answer: A

Solution:

$\mathrm{i}=\sqrt{2} \mathrm{~A}$

$\mathrm{B}_{\text {net }}=\sqrt{\mathrm{B}_1^2+\mathrm{B}_2^2}$

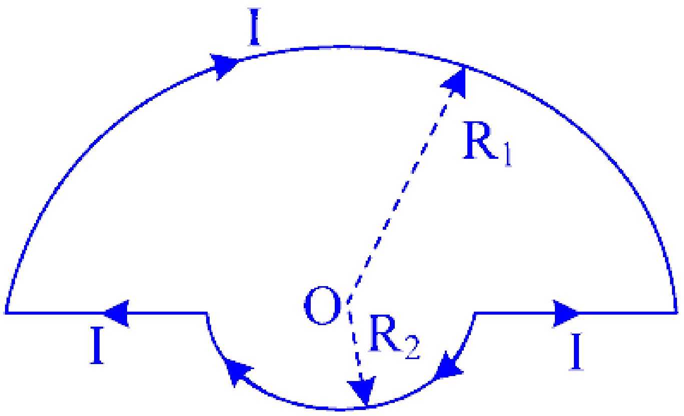
$$= \sqrt{\left(\frac{\mu_0 i}{2R}\right)^2 + \left(\frac{\mu_0 i}{2R}\right)^2} = \sqrt{2\left(\frac{\mu_0 i}{2R}\right)^2}$$

$$= \sqrt{2\frac{\mu_0^2 i^2}{4R^2}} = \sqrt{\frac{1}{2}\left(\frac{\mu_0 i}{R}\right)^2}$$

$$= \frac{1}{\sqrt{2}}\frac{\mu_0 \mathrm{i}}{\mathrm{R}} = \frac{1}{\sqrt{2}} \times \frac{\mu_0\sqrt{2}}{1} = \mu_0$$

Question76

Figure shows two semicircular loops of radii R_1 and R_2 carrying current I. The magnetic field at the common centre 'O' is



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Options:

A. $\frac{\mu_0 \mathrm{I}}{4}\left(\frac{1}{\mathrm{R}_1} + \frac{1}{\mathrm{R}_2}\right)$

B. $\frac{\mu_0 \mathrm{I}}{4}\left(\frac{1}{\mathrm{R}_1} - \frac{1}{\mathrm{R}_2}\right)$

C. $\frac{\mu_0 \mathrm{I}}{2\pi}\left(\frac{1}{\mathrm{R}_1} + \frac{1}{\mathrm{R}_2}\right)$

D. $\frac{\mu_0 I}{2\pi}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Answer: A

Solution:

For semicircular arc the magnetic field is given as $B=\frac{\mu_0 i}{4R}$

The equivalent magnetic field at the centre is

$$\begin{aligned} B_{\text{eq}} &= \frac{\mu_0 I}{4R_1}+\frac{\mu_0 I}{4R_2} \\ B_{\text{eq}} &= \frac{\mu_0 I}{4}\left(\frac{1}{R_1}+\frac{1}{R_2}\right) \end{aligned}$$

Question77

A long wire is bent into a circular coil of one turn and then into a circular coil of smaller radius having n turns. If the same current passes in both the cases, the ratio of magnetic fields produced at the centre for one turn to that of n turns is

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Options:

A. 1 : n

B. n : 1

C. 1 : n^2

D. n^2 : 1

Answer: C

Solution:

Magnetic field at the centre of coil is,

$B_1=\frac{\mu_0 I}{2r_1}$

$\therefore$ Magnetic field of n turns coil at the centre:

$$B_2 = \frac{\mu_0 n I}{2r_2}$$

$$\therefore \quad \frac{B_1}{B_2} = \frac{\frac{\mu_0 I}{2r_1}}{\frac{\mu_0 n I}{2r_2}} = \frac{r_2}{\mathrm{nr}_1}$$

But, radius: $r_1 = \frac{1}{2\pi}$ and $r_2 = \frac{1}{2\pi n}$

$$\therefore \quad \frac{\mathrm{r}_2}{\mathrm{r}_1} = \frac{1}{\mathrm{n}}$$

$$\therefore \quad \frac{\mathrm{B}_1}{\mathrm{B}_2} = \frac{1}{\mathrm{n}^2}$$

Question78

A horizontal wire of mass 'm', length 'l' and resistance 'R' is sliding on the vertical rails on which uniform magnetic field 'B' is directed perpendicular. The terminal speed of the wire as it falls under the force of gravity is ($\mathrm{g}=$ acceleration due to gravity)

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Options:

A. $\frac{\mathrm{mg}l}{\mathrm{BR}}$

B. $\frac{\mathrm{B}^2 l^2}{\mathrm{mgR}}$

C. $\frac{\mathrm{mgR}}{\mathrm{Bl}}$

D. $\frac{\mathrm{mgR}}{\mathrm{B}^2 l^2}$

Answer: D

Solution:

Net force on the wire becomes zero when it attains terminal velocity.

$\therefore$ Force due to magnetic field = gravitational force

$\therefore$ $\mathrm{iB}l = \mathrm{mg}$

$\therefore$ $\frac{\mathrm{e}}{\mathrm{R}}\mathrm{B}l = \mathrm{mg} \quad \ldots\left(\because i = \frac{e}{R}\right)$

$\therefore$ $\frac{\mathrm{Bv}l}{\mathrm{R}}\mathrm{B}l = \mathrm{mg} \quad \ldots(\because \mathrm{e} = \mathrm{Bv}l)$

$\therefore$ $\mathrm{v} = \frac{\mathrm{mgR}}{\mathrm{B}^2 l^2}$

Question79

A straight wire carrying a current (I) is turned into a circular loop. If the magnitude of the magnetic moment associated with it is 'M', then the length of the wire will be

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Options:

A. $\frac{\mathrm{M}\pi}{4\mathrm{I}}$

B. $\left[\frac{4\pi I}{M}\right]^{\frac{1}{2}}$

C. $\left[\frac{4\mathrm{M}\pi}{\mathrm{I}}\right]^{\frac{1}{2}}$

D. $4\pi\mathrm{MI}$

Answer: C

Solution:

Magnetic moment is given as $M = IA$

$\therefore$ $\mathrm{M} = \mathrm{I}\left(\pi\mathrm{R}^2\right)$

Now, length of the wire is, $L = 2\pi R$

$$\therefore \quad R = \frac{L}{2\pi}$$

$$\Rightarrow \quad M = I\pi\left(\frac{L}{2\pi}\right)^2$$

$$\therefore \quad L = \sqrt{\frac{4M\pi}{I}}$$

Question80

A solenoid of length 0.4 m and having 500 turns of wire carries a current 3 A. A thin coil having 10 turns of wire and radius 0.1 m carries current 0.4 A. the torque required to hold the coil in the middle of the solenoid with its axis perpendicular to the axis of the solenoid is $\left(\mu_0 = 4\pi \times 10^{-7}\right.$ SI units, $\left.\pi^2 = 10\right)$ $(\sin 90^\circ = 1)$

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Options:

A. $3 \times 10^{-6} \text{ Nm}$

B. $12 \times 10^{-6} \text{ Nm}$

C. $6 \times 10^{-4} \text{ Nm}$

D. $24 \times 10^{-6} \text{ Nm}$

Answer: C

Solution:

The equation for torque is given by:

$\tau = \text{NIAB} \sin\theta$

As axis of coil and solenoid are perpendicular to each other, $\theta = 90^\circ$ and $\sin\theta = 1$

$$\begin{aligned} \therefore \quad \tau &= \mu_0 \text{nI}_1 \times \text{ NIA} \\ &= 4\pi \times 10^{-7} \times \frac{500}{0.4} \times 3 \times 10 \times 0.4 \times \pi \times 10^{-2} \\ \tau &= 6 \times 10^{-4} \text{Nm} \end{aligned}$$

Question81

Two circular coils made from same wire but radius of 1^{st} coil is twice that of 2^{nd} coil. If magnetic field at their centres is same then ratio of potential difference applied across them is (1^{st} to 2^{nd} coil)

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Options:

A. 2

B. 3

C. 4

D. 6

Answer: C

Solution:

Magnetic fields at the centre of the coils are equal.

$$\therefore \quad \frac{\mu_0 I_1}{2r_1} = \frac{\mu_0 I_2}{2r_2}$$

$$\therefore \quad \frac{I_1}{I_2} = \frac{r_1}{r_2} = \frac{2r}{r} \quad \ldots(\text{given } \mathrm{r}_1 = 2\mathrm{r}_2)$$

$$\therefore \quad \frac{I_1}{I_2} = 2 \quad \ldots.(\mathrm{i})$$

The resistance through the coil,

$\mathrm{R} \propto l$

Here, $l = 2\pi\mathrm{r}$

$$\therefore \quad \frac{\mathrm{R}_1}{\mathrm{R}_2} = \frac{2\pi\mathrm{r}_1}{2\pi\mathrm{r}_2} = 2 \quad \ldots.(\mathrm{ii})$$

$$\therefore \quad \frac{\mathrm{V}_1}{\mathrm{V}_2} = \frac{\mathrm{I}_1\mathrm{R}_1}{\mathrm{I}_2\mathrm{R}_2} = 2 \times 2 = 4 \quad \ldots[\text{From (i) and (ii)}]$$

Question82

The ratio of magnetic field at the centre of the current carrying circular loop and magnetic moment is X. When both the current and radius are doubled, then the ratio will be

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Options:

A. $2X$

B. $\frac{X}{2}$

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

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

Answer: D

Solution:

The magnetic field at the centre of a current carrying loop is

$B=\frac{\mu_0}{4\pi}\left(\frac{2\pi I}{a}\right)=\frac{\mu_0 l}{2a}$ ..... (i)

and magnetic moment M is

$M=I\left(\pi a^2\right)$ .... (ii)

Thus, $\quad X=\frac{B}{M}=\frac{\mu_0 I}{2a}\times\frac{I}{I\pi a^2}=\frac{\mu_0}{2\pi a^3}$ .... (iii)

Now, according to question, when both the current and radius are doubled, then the ratio will be

$\Rightarrow \frac{\mu_0}{2\pi(2a)^3}=\frac{\mu_0}{8\left(2\pi a^3\right)}$

From Eq. (iii), $\frac{\mu_0}{2\pi a^3}=X$

So, $\frac{\mu_0}{8\left(2\pi a^3\right)}=\frac{X}{8}$

Question83

A circular current carrying coil has radius R. The magnetic induction at the centre of the coil is B_C. The magnetic induction of

the coil at a distance $\sqrt{3}R$ from the centre along the axis is B_A. The ratio $B_A : B_C$ is

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Options:

A. 1 : 3

B. 1 : 8

C. 8 : 1

D. 27 : 1

Answer: B

Solution:

Magnetic field on the axis of a circular coil,

$B_A = \frac{\mu_0 i R^2}{2(R^2+Z^2)^{3/2}}$

Magnetic field at the centre of the circular coil,

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

According to question,

$$\begin{aligned} B_A &= \frac{\mu_0 i R^2}{2(R^2+3R^2)^{3/2}} \quad (\because Z = \sqrt{3}R) \\ \Rightarrow \quad B_A &= \frac{\mu_0 i R^2}{2 \times (4R^2)^{3/2}} \\ \Rightarrow \quad \frac{\mu_0 i R^2}{2 \times 8 \times R^3} &= \frac{\mu_0 i R^2}{8 \times 2R^3} \\ &= \frac{\mu_0 i}{8 \times 2R} \end{aligned}$$

Thus, the ratio, $B_A : B_C = 1 : 8$

Question84

A circular coil of radius 'r' and number of turns ' n ' carries a current 'I'. The magnetic fields at a small distance 'h' along the axis of the coil (B_a) and at the centre of the coil $(\mathrm{B_c})$ are measured. The relation between B_c and B_a is

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Options:

A. $\mathrm{B_c = B_a\left(1+\frac{h^2}{r^2}\right)}$

B. $\mathrm{B_c = B_a\left(1+\frac{h^2}{r^2}\right)^{\frac{1}{2}}}$

C. $\mathrm{B_c = B_a\left(1+\frac{h^2}{r^2}\right)^{\frac{3}{2}}}$

D. $\mathrm{B_c = B_a\left(1+\frac{h^2}{r^2}\right)^{-\frac{3}{2}}}$

Answer: C

Solution:

Magnetic field along the axis of the coil is:

$\mathrm{B_a} = \frac{\mu_0}{4\pi}\left[\frac{2\pi n \mathrm{Ir^2}}{\mathrm{(r^2+h^2)^{\frac{3}{2}}}}\right]$ .... (i)

Magnetic field at the centre of the coil is:

$$\mathrm{B_C} = \frac{\mu_0}{4\pi}\left(\frac{2\pi n \mathrm{I}}{\mathrm{r}}\right) \quad \text{.... (ii)}$$

$$\frac{\mathrm{B_C}}{\mathrm{B_a}} = \frac{\mathrm{(r^2+h^2)^{\frac{3}{2}}}}{\mathrm{r^3}}$$

$$\therefore \quad \mathrm{B_C = B_a\left[1+\frac{h^2}{r^2}\right]^{\frac{3}{2}}}$$

Question85

Two concentric circular coils A and B have radii 20 cm and 10 cm respectively lie in the same plane. The current in coil A is 0.5 A in anticlockwise direction. The current in coil B so that net field at the common centre is zero, is

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Options:

A. 0.5 A in anticlockwise direction

B. 0.25 A in anticlockwise direction.

C. 0.25 A in clockwise direction.

D. 0.125 A in clockwise direction.

Answer: C

Solution:

Magnetic field at the centre of a circular loop

$B = \frac{\mu_0 NI}{2R}$

Net Magnetic field $B_{net} = 0$(given)

$$\Rightarrow B_{net} = \frac{\mu_0 N_1 \times 0.5}{2 \times (0 \cdot 2)} - \frac{\mu_0 N_1 \times x}{2 \times (0 \cdot 1)}$$

$$\Rightarrow \frac{\mu_0 N_1 x}{0.2} = \frac{\mu_0 N_1 0.5}{0.4}$$

$$\therefore \quad x = \frac{0.5 \times 0.2}{0.4}$$

$$= 0.25 \text{ A in clockwise direction}$$

Question86

Two concentric circular coils of 10 turns each are situated in the same plane. Their radii are 20 cm and 40 cm and they carry respectively 0.2 A and 0.3 A current in opposite direction. The magnetic field at the centre is ($\mu_0 = 4\pi \times 10^{-7}$ SI units)

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Options:

A. $4\pi \times 10^{-7}$ T

B. $5\pi \times 10^{-7}$ T

C. $2\pi \times 10^{-5}$ T

D. $7\pi \times 10^{-6}$ T

Answer: B

Solution:

$$\begin{aligned} B_{\text{net}} & =\frac{\mu_0 n_1 I_1}{2 r_1}-\frac{\mu_0 n_2 I_2}{2 r_2} \\ & =\frac{10 \mu_0}{2}\left[\frac{0.2}{0.2}-\frac{0.3}{0.4}\right] \\ & =5 \times 4 \pi \times 10^{-7} \times 0.25 \\ & =5 \pi \times 10^{-7} \mathrm{~T}\end{aligned}$$

Question87

A coil of 'n' turns and radius 'R' carries a current 'I'. It is unwound and rewound again to make another coil of radius $\left(\frac{\mathrm{R}}{3}\right)$, current remaining the same. The ratio of magnetic moment of the new coil to that of original coil is

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Options:

A. 3 : 1

B. 1 : 3

C. 9 : 1

D. 1 : 9

Answer: B

Solution:

As the length of the wire remains the same, we can write

$$N_1 2\pi R = N_2 \times 2\pi \frac{R}{3}$$
$$N_1 = \frac{N_2}{3}$$
$$N_2 = 3N_1$$

Magnetic moment of coil $\mu =$ NIA

$\therefore \quad \mu_1 = N_1 I A_1 = N_1 I \pi R^2$

$\therefore \quad \mu_2 = N_2 I A_2 = 3\frac{N_1 I \pi R^2}{9}$

$\therefore \quad \frac{\mu_2}{\mu_1} = 3\frac{N_1 I \pi R^2}{9} \times \frac{1}{N_1 I \pi R^2} = \frac{1}{3}$

Question88

An electron makes a full rotation in a circle of radius 0.8 m in one second. The magnetic field at the centre of the circle is $\left(\mu_0 = 4\pi \times 10^{-7}\right.$ SI units)

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Options:

A. $4\pi \times 10^{-26}$ T

B. $2\pi \times 10^{-26}$ T

C. $4\pi \times 10^{-19}$ T

D. $2\pi \times 10^{-19}$ T

Answer: A

Solution:

$$\omega = \frac{2\pi}{T}$$

$$I = \frac{q\omega}{2\pi} = \frac{1.6 \times 10^{-19} \times 2\pi}{2\pi} \quad \ldots . \left(\because I = \frac{q}{t}\right)$$

$$I = 1.6 \times 10^{-19} \text{ A}$$

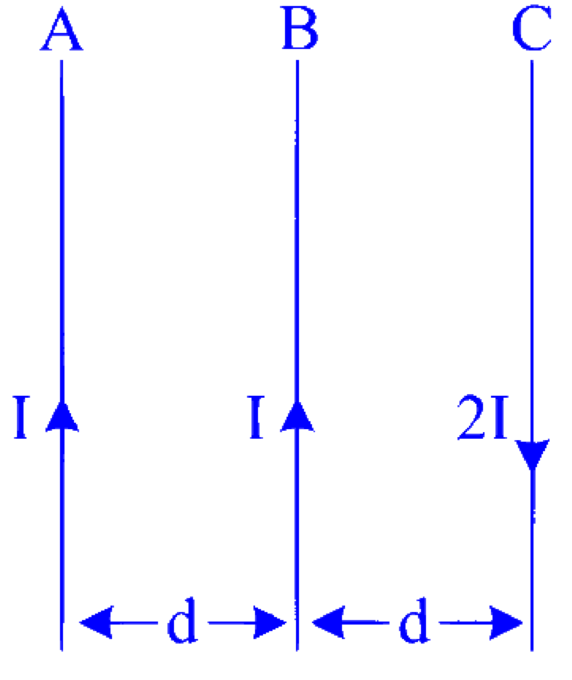
$\therefore$ The magnetic field at the centre of the circle is:

$$\mathrm{B} = \frac{\mu_0 \mathrm{I}}{2\mathrm{r}} = \frac{4\pi \times 10^{-7} \times 1.6 \times 10^{-19}}{2 \times 0.8}$$

$$\mathrm{B} = 4\pi \times 10^{-26} \text{ T}$$

Question89

A, B and C are three parallel conductors of equal lengths and carry currents I, I and 2I respectively as shown in figure. Distance AB and BC is same as 'd'. If 'F_1' is the force exerted by B on A and F_2 is the force exerted by C on A, then



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Options:

A. $F_1 = F_2$

B. $F_1 = -F_2$

C. $F_1 = 2F_2$

D. $\mathrm{F}_1 = \frac{1}{2}\mathrm{~F}_2$

Answer: B

Solution:

Force per unit length exerted by B on A, $\mathrm{F}_1 = \frac{\mu_0(\mathrm{I})(\mathrm{I})}{2\pi\mathrm{d}} = \frac{\mu_0\mathrm{I}^2}{2\pi\mathrm{d}}$ (outside the plane of paper)

Force per unit length exerted by C on A,

$\mathrm{F}_2 = \frac{\mu_0(\mathrm{I})(2\mathrm{I})}{2\pi(2\mathrm{~d})} = \frac{\mu_0\mathrm{I}^2}{2\pi\mathrm{d}}$ (Inside the plane of paper)

$\therefore \quad F_1 = -F_2$

Question90

The magnetic moment of a current (I) carrying circular coil of radius 'r' and number of turns 'n' depends on

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Options:

A. n only

B. I only

C. r only

D. n, I and r

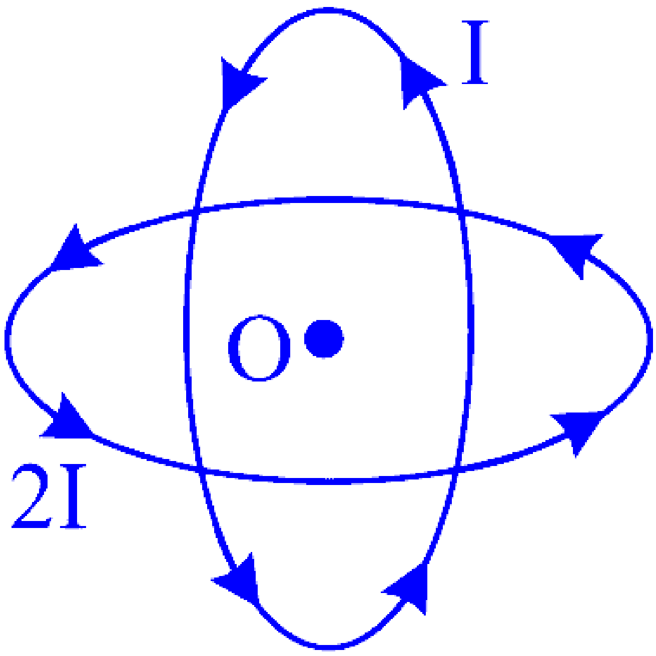
Answer: D

Solution:

$m = nIA$
$m = nI(\pi r^2)$

Question91

Two similar coils each of radius R are lying concentrically with their planes at right angles to each other. The current flowing in them are I and 2I. The resultant magnetic field of induction at the centre will be (μ_0 = Permeability of vacuum)



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Options:

A. $\frac{\mu_0 I}{2R}$

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

C. $\frac{3\mu_0 I}{2R}$

D. $\frac{\sqrt{5}\mu_0 I}{2R}$

Answer: D

Solution:

$B_1 = \frac{\mu_0 I}{2R}, B_2 = \frac{\mu_0 (2I)}{2R}$

Resultant magnetic field, $B = \sqrt{B_1 + B_2}$

$\therefore \quad B = \sqrt{\left(\frac{\mu_0 I}{2R}\right)^2 + \left(\frac{\mu_0 (2I)}{2R}\right)^2}$

$\therefore \quad B = \frac{\mu_0 I}{2R} \sqrt{1^2 + 2^2}$

$\therefore \quad B = \frac{\sqrt{5} \mu_0 I}{2R}$

Question92

A single turn current loop in the shape of a right angle triangle with side $5 \mathrm{~cm}, 12 \mathrm{~cm}, 13 \mathrm{~cm}$ is carrying a current of $2 \mathrm{~A}$. The loop is in a uniform magnetic field of magnitude $0.75 \mathrm{~T}$ whose direction is parallel to the current in the $13 \mathrm{~cm}$ side of the loop. The magnitude of the magnetic force on the $5 \mathrm{~cm}$ side will be $\frac{\mathrm{x}}{130} \mathrm{~N}$. The value of '$x$' is

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Options:

A. 4

B. 9

C. 12

D. 15

Answer: B

Solution:

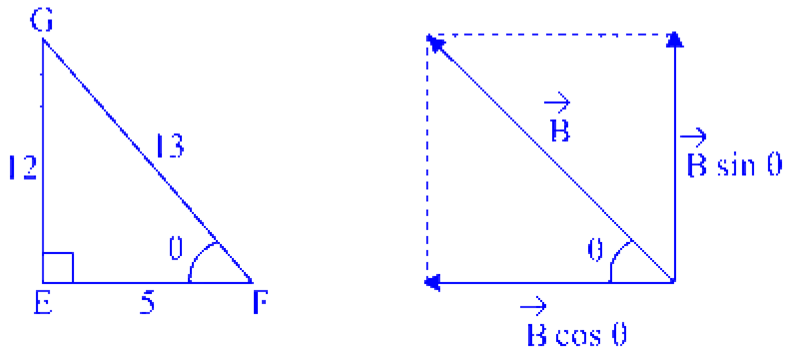

Figure (a) Figure (b)

The net magnetic field is acting in the direction of GF as shown in figures.

Resolving $\overrightarrow{\mathrm{B}}$ into its components, amongst the components, only $\vec{B}\sin\theta$ exerts force on side EF of current carrying loop.

$\therefore \quad \mathrm{F}_{\mathrm{EF}}=\mathrm{I}\times\mathrm{d}(\mathrm{EF})\times\mathrm{B}\sin\theta$

From figure (a), $\sin\theta=\frac{12}{13}$

$\therefore \quad \mathrm{F}_{\mathrm{EF}}=2\times0.05\times0.75\times\frac{12}{13}$

$\therefore \quad \mathrm{F}_{\mathrm{EF}}=\frac{9}{130}\ \mathrm{N}$

$\therefore \quad \mathrm{x}=9$

Question93

Two long conductors separated by a distance 'd' carry currents I_1 and I_2 in the same direction. They exert a force 'F' on each other. Now the current in one of them is increased to two times and its direction is reversed. The distance between them is also increased to 3 d. The new value of force between them is

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Options:

A. $-2\ \mathrm{F}$

B. $\frac{\mathrm{F}}{3}$

C. $\frac{-2 \mathrm{~F}}{3}$

D. $\frac{-\mathrm{F}}{3}$

Answer: C

Solution:

The force per unit length of the conductors is given as:

$\mathrm{F}=\frac{\mu_0 \mathrm{I}_1 \mathrm{I}_2}{2 \pi \mathrm{d}}$

When the value and direction of current in the first conductor and the distance between the conductors are changed,

$$\begin{aligned} \therefore \quad \mathrm{F}_2 & =\frac{-\mu_0 2 \mathrm{I}_1 \mathrm{I}_2}{2 \pi \times 3 \mathrm{~d}} \\ \therefore \quad \frac{\mathrm{F}_2}{\mathrm{~F}} & =\frac{-2}{3} \\ \mathrm{~F}_2 & =-\frac{2 \mathrm{~F}}{3} \end{aligned}$$

Question94

A circular arc of radius 'r' carrying current 'I' subtends an angle $\frac{\pi}{16}$ at its centre. The radius of a metal wire is uniform. The magnetic induction at the centre of circular arc is $[\mu_0=$ permeability of free space]

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Options:

A. $\frac{\mu_0 \mathrm{I}}{32 \mathrm{r}}$

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

C. $\frac{\mu_0 \mathrm{I}}{64 \mathrm{r}}$

D. $\frac{\mu_0 \mathrm{I}}{8 \mathrm{r}}$

Answer: C

Solution:

The magnetic field due to current carrying circular arc is $B = \frac{\mu_0 I}{2r}\left(\frac{\theta}{2\pi}\right)$

Here, $\theta = \frac{\pi}{16}$

$$\therefore \quad \mathrm{B} = \frac{\mu_0 \mathrm{I}}{2\mathrm{r}}\left(\frac{1}{2\pi} \times \frac{\pi}{16}\right)$$
$$\mathrm{B} = \frac{\mu_0 \mathrm{I}}{2\mathrm{r}}\left(\frac{1}{32}\right)$$
$$\mathrm{B} = \frac{\mu_0 \mathrm{I}}{64\mathrm{r}}$$

Question95

A cylindrical magnetic rod has length $5 \mathrm{~cm}$ and diameter $1 \mathrm{~cm}$. It has uniform magnetization $5.3 \times 10^3 \mathrm{~A/m}^3$. Its net magnetic dipole moment is nearly

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Options:

A. $1 \times 10^{-2} \mathrm{~J/T}$

B. $0.5 \times 10^{-2} \mathrm{~J/T}$

C. $2.5 \times 10^{-2} \mathrm{~J/T}$

D. $2 \times 10^{-2} \mathrm{~J/T}$

Answer: D

Solution:

Magnetisation, $M = \frac{m_{net}}{V}$

$$\therefore \quad m_{net} = M \times V = M \times (\pi r^2 l) = M \times \pi \times \frac{d^2}{4} \times l$$
$$= 5.3 \times 10^3 \times 3.142 \times \left(\frac{1 \times 10^{-2}}{2}\right)^2 \times 5 \times 10^{-2}$$
$$= 2.08 \times 10^{-2}\ J/T$$

Question96

Two parallel wires of equal lengths are separated by a distance of $3\ \mathrm{m}$ from each other. The currents flowing through 1^{st} and 2^{nd} wire is $3\ \mathrm{A}$ and 4.5 A respectively in opposite directions. The resultant magnetic field at mid point between the wires ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0}{2\pi}$

B. $\frac{3\mu_0}{2\pi}$

C. $\frac{7\mu_0}{2\pi}$

D. $\frac{5\mu_0}{2\pi}$

Answer: D

Solution:

Using Biot Savart law,

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

$\therefore$ Magnetic field due to first wire:

$B_1 = \frac{\mu_0 I_1}{2\pi r} = \frac{\mu_0 \times 3}{2\pi \times 1.5} = \frac{2\mu_0}{2\pi}$

$\therefore$ Magnetic field due to second wire:

$B_2 = \frac{\mu_0 I_2}{2\pi r} = \frac{\mu_0 \times 4.5}{2\pi \times 1.5} = \frac{3\mu_0}{2\pi}$

$\therefore$ Net field,

$B = B_1 + B_2 = \frac{2\mu_0}{2\pi} + \frac{3\mu_0}{2\pi} = \frac{5\mu_0}{2\pi}$

Question97

An electron is projected along the axis of circular conductor carrying current I. Electron will experience

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Options:

A. no force.

B. a force along the axis.

C. a force at angle 30° with the axis.

D. a force perpendicular to axis.

Answer: A

Solution:

The magnetic force experienced by the electron, $F = qvB \sin \theta$

As electron is projected along the axis, $\theta = 0$

$\therefore \quad F = 0$

Question98

The magnetic field at the centre of a circular coil of radius 'R', carrying current $2A$ is 'B_1'. The magnetic field at the centre of another coil of radius '$3R$' carrying current $4A$ is 'B_2'. The ratio $B_1 : B_2$ is

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Options:

A. 1 : 2

B. 2 : 1

C. 2 : 3

D. 3 : 2

Answer: D

Solution:

$$\begin{aligned} & \mathrm{B}_1=\frac{\mu_0}{4 \pi} \times \frac{2 \pi \times 2}{\mathrm{R}}=\frac{\mu_0}{\mathrm{R}} \\ & \mathrm{B}_2=\frac{\mu_0}{4 \pi} \times \frac{2 \pi \times 4}{3 \mathrm{R}}=\frac{2 \mu_0}{3 \mathrm{R}} \\ \therefore & \frac{\mathrm{B}_1}{\mathrm{B}_2}=\frac{\left(\frac{\mu_0}{\mathrm{R}}\right)}{\frac{2 \mu_0}{(3 \mathrm{R})}}=\frac{3}{2} \end{aligned}$$

Question99

Two wires $2 \mathrm{~mm}$ apart supply current to a $100 \mathrm{~V}, 1 \mathrm{~kW}$ heater. The force per metre between the wires is ($\mu_0=4 \pi \times 10^{-27}$ SI unit)

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Options:

A. $2 \times 10^{-2} \mathrm{~N}$

B. $4 \times 10^{-3} \mathrm{~N}$

C. $2 \times 10^2 \mathrm{~N}$

D. $10^{-2} \mathrm{~N}$

Answer: D

Solution:

$$\text{Given: } P = 1\text{ W} = 1000\text{ W},\ \text{V} = 100\text{ V}$$

$$\therefore \quad I = 10\text{ A} \quad \ldots .(\because \text{P} = \text{VI})$$

$$\therefore \quad \text{F} = \frac{\mu_0 \text{I}_1 \text{I}_2}{2\pi \times \text{a}} = \frac{4\pi \times 10^{-7} \times 100}{2\pi \times \left(2 \times 10^{-3}\right)} = 10^{-7} \times 10^5 = 10^{-2}\text{ N}$$

Question100

Two long parallel wires carrying currents 8 A and 15 A in opposite directions are placed at a distance of 7 cm from each other. A point 'P' is at equidistant from both the wires such that the lines joining the point to the wires are perpendicular to each other. The magnitude of magnetic field at point 'P' is $(\sqrt{2} = 1.4)(\mu_0 = 4\pi \times 10^{-7}$ SI units)

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Options:

A. $68 \times 10^{-6}\text{ T}$

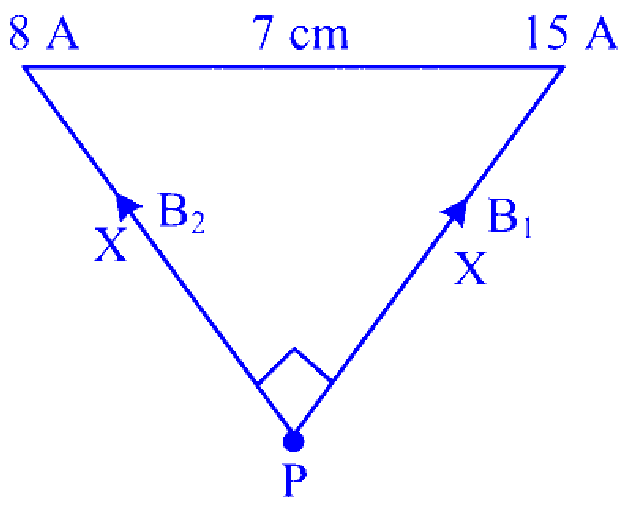
B. $48 \times 10^{-6}\text{ T}$

C. $32 \times 10^{-6}\text{ T}$

D. $16 \times 10^{-6}\text{ T}$

Answer: A

Solution:



Magnetic field produced by two wires

$B_1=\frac{\mu_0 I_1}{2\pi X}$ and $B_2=\frac{\mu_0 I_2}{2\pi X}$

From Figure,

$$\begin{aligned} \mathrm{B}_{\text{net}} & =\sqrt{\mathrm{B}_1^2+\mathrm{B}_2^2} \\ & =\frac{\mu_0}{2\pi\mathrm{X}}\sqrt{\mathrm{I}_1^2+\mathrm{I}_2^2} \end{aligned}$$

Also, using Pythagoras theorem, $2X^2=7\times 7$ cm

$$\therefore \quad \mathrm{X}=\frac{7}{\sqrt{2}}\text{ cm}$$

$$\begin{aligned} \mathrm{B}_{\text{net}} & =\frac{4\pi\times 10^{-7}}{2\pi\times\frac{7}{\sqrt{2}}\times 10^{-2}}\sqrt{15^2+8^2} \\ & \approx 68\times 10^{-6}\text{ T} \end{aligned}$$

Question101

Electron of mass 'm' and charge 'q' is travelling with speed 'v' along a circular path of radius 'R', at right angles to a uniform magnetic field of intensity 'B'. If the speed of the electron is halved and the magnetic field is doubled, the resulting path would have radius

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Options:

A. 4R

B. 2R

C. $\frac{R}{2}$

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

Answer: D

Solution:

From cyclotron motion and uniform circular motion,

i.e., $qvB \sin 90^{\circ}=\frac{mv^2}{R}$

$\therefore \quad R=\frac{mv}{qB}$

Given: $v^{\prime}=\frac{v}{2}$ and $B^{\prime}=2 B$

$$\begin{aligned} \therefore \quad R^{\prime} & =\frac{mv^{\prime}}{qB^{\prime}} \\ & =\frac{m \frac{v}{2}}{q 2 B}=\frac{1}{4} \frac{mv}{qB} \\ \Rightarrow R^{\prime} & =\frac{1}{4} R \end{aligned}$$

Question102

10 A current is flowing in two straight parallel wires in the same direction. Force of attraction between them is 1×10^{-3} N. If the current is doubled in both the wires the force will be

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Options:

A. 1×10^{-3} N

B. 2×10^{-3} N

C. 4×10^{-3} N

D. 0.25×10^{-3} N

Answer: C

Solution:

$F = \frac{\mu_0}{4\pi} \frac{2I_1I_2}{r} l = 10^{-3}$ N

When current in both the wires is doubled, then

$F' = \frac{\mu_0}{4\pi} \frac{2(2I_1 \times 2I_2)}{r} l = 4 \times 10^{-3}$ N

Question103

The magnetic field at a point P situated at perpendicular distance 'R' from a long straight wire carrying a current of 12 A is $3 \times 10^{-5}\ \mathrm{Wb/m^2}$. The value of 'R' in mm is $\left[\mu_0 = 4\pi \times 10^{-7}\ \mathrm{Wb/Am}\right]$

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Options:

A. 0.08

B. 0.8

C. 8

D. 80

Answer: D

Solution:

Using Biot-Savart's Law,

$$B = \frac{\mu_0 I}{2\pi R}$$

$$\therefore \quad R = \frac{\mu_0 I}{2\pi B}$$

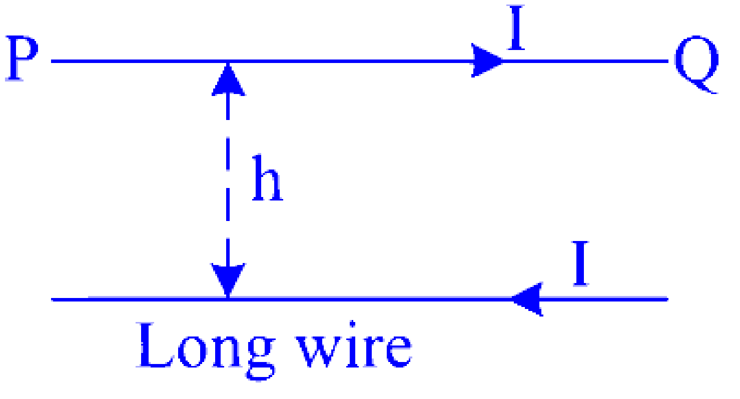
$$= \frac{4\pi \times 10^{-7} \times 12}{2\pi \times 3 \times 10^{-5}}$$

$$= 8 \times 10^{-2} \text{ m}$$

$$= 80 \text{ mm}$$

Question104

A long straight wire carrying a current of 25 A rests on the table. Another wire PQ of length 1 m and mass 2.5 g carries the same current but in the opposite direction. The wire PQ is free to slide up and down. To what height will wire PQ rise? ($\mu_0 = 4\pi \times 10^{-7}$ SI unit)



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Options:

A. 3 mm

B. 4 mm

C. 5 mm

D. 8 mm

Answer: C

Solution:

Given $I_1 = I_2 = 25\ A, l = 1\ m$,

$$B = \frac{\mu_0 I}{2\pi h}$$
$$F = BIl\sin\theta = BIl$$

Force applied on PQ = Weight of the smaller current carrying wire

$$\text{i.e, } mg = \frac{\mu_0 I^2 l}{2\pi h}$$
$$\therefore \quad h = \frac{4\pi\times10^{-7}\times250\times25\times1}{2\pi\times2.5\times10^{-3}\times9.8} = 5\ mm$$

Question105

Two parallel conducting wires of equal length are placed distance 'd' apart, carry currents 'I_1' and 'I_2' respectively in opposite directions. The resultant magnetic field at the midpoint of the distance between both the wires is

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Options:

A. $\frac{\mu_0(I_1-I_2)}{\pi d}$

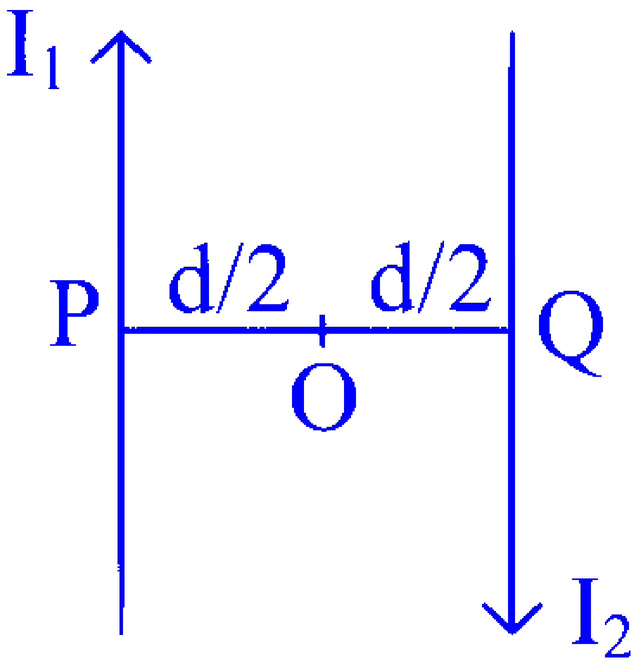
B. $\frac{\mu_0(I_1+I_2)}{2\pi d}$

C. $\frac{\mu_0(I_1-I_2)}{2\pi d}$

D. $\frac{\mu_0(I_1+I_2)}{\pi d}$

Answer: D

Solution:



The magnetic field at O, due to current in P is

$$B_1=\frac{\mu_0}{4\pi}\left(\frac{2I_1}{d/2}\right)=\frac{\mu_0}{4\pi}\times\frac{4I_1}{d}=\frac{\mu_0 I_1}{\pi d}$$

and the magnetic field at O due to current I_2 in the wire Q is

$$B_2=\frac{\mu_0}{4\pi}\left(\frac{2I_2}{d/2}\right)=\frac{\mu_0}{4\pi}\times\frac{4I_2}{d}=\frac{\mu_0 I_2}{\pi d}$$

The currents in the wires are in opposite directions.

Hence the magnetic fields will be added.

$\therefore$ Resultant field $B=B_1+B_2=\frac{\mu_0}{\pi d}(I_1+I_2)$

Question106

An electron and a proton having the same momenta enter perpendicularly into a magnetic field. What are their trajectories in the field?

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Options:

A. Path of the electron is more curved than that of proton

B. They will travel undeflected

C. Path of the proton is more curved than that of the electron

D. Both the electron and the proton will move along the same curved path but they will move in opposite directions

Answer: D

Solution:

The force produced by the magnetic field on a moving charged particle is $F = qvB$ and this gives a C.P. force

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

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

$$\therefore r = \frac{mv}{qB} = \frac{p}{qB} \text{ where } p = \text{ momentum}$$

It is given that both the particles (electron and proton) have the same momenta.

Similarly they have the same charge in magnitude (e and $-e$) and they move in the same field (B).

$$\therefore \frac{r_1}{r_2} = \frac{p_1}{q_1 B} \times \frac{q_2 B}{p_2} = 1$$

$$\because p_1 = p_2 \text{ and } q_1 = q_2$$

$$\therefore r_1 = r_2$$

$\therefore$ They will describe the same curved path.

[One will move clockwise and the other anticlockwise.]

Question107

A solenoid 2 m long and 4 cm in diameter has 4 layers of windings of 1000 turns each and carries a current of 5 A. What is the magnetic field at its centre along the axis? [$\mu_0 = 4\pi \times 10^{-7}$ Wb/Am]

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Options:

A. 10^{-3} T

B. $2\pi \times 10^{-3}$ T

C. $4\pi \times 10^{-3}$ T

D. $8\pi \times 10^{-3}$ T

Answer: C

Solution:

$$\mathrm{B} = \mu_0 \mathrm{nI}$$
$$\mathrm{n} = \frac{\mathrm{N}}{\mathrm{L}} = \frac{4 \times 1000}{2} = 2000/\mathrm{m}, \mathrm{I} = 5\ \mathrm{A}$$
$$\therefore \quad B = 4\pi \times 10^{-7} \times 2000 \times 5$$
$$= 4\pi \times 10^{-3}\ \mathrm{T}$$

Question108

A particle of charge 'q' and mass 'm' moves in a circular orbit of radius 'r' with angular speed 'ω'. The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on

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Options:

A. ω and q

B. ω and m

C. q and m

D. ω, q and m

Answer: C

Solution:

To determine the ratio of the magnitude of the magnetic moment to the angular momentum for a particle of charge 'q' and mass 'm' moving in a circular orbit of radius 'r' with angular speed ω, we need to calculate each quantity separately and then find their ratio.

Magnetic Moment (M):

The magnetic moment for a charged particle moving in a circular orbit is given by:

$M = \frac{q}{2m} \cdot L$

where L is the angular momentum of the particle.

Angular Momentum (L):

Angular momentum for a particle moving in a circle is:

$L = m \cdot r^2 \cdot \omega$

Substituting L into the Magnetic Moment formula:

$M = \frac{q}{2m} \cdot (m \cdot r^2 \cdot \omega)$

$M = \frac{q \cdot r^2 \cdot \omega}{2}$

Ratio of Magnetic Moment to Angular Momentum:

We need to find the ratio $\frac{M}{L}$.

$\frac{M}{L} = \frac{\frac{q \cdot r^2 \cdot \omega}{2}}{m \cdot r^2 \cdot \omega}$

$\frac{M}{L} = \frac{q}{2m}$

From this ratio, it is clear that the ratio of the magnitude of its magnetic moment to that of its angular momentum depends only on the charge 'q' and mass 'm' of the particle.

Thus, the correct option is:

Option C

q and m

Question109

A current carrying loop is placed in a uniform magnetic field. The torque acting on the loop does not depend upon

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Options:

A. area of loop

B. number of turns in the loop

C. shape of the loop

D. strength of the magnetic field

Answer: C

Solution:

The correct answer is **Option C - shape of the loop**. Here's why:

The torque (τ) acting on a current-carrying loop in a uniform magnetic field is given by:

$\tau = NIABsin\theta$

Where:

- N is the number of turns in the loop
- I is the current flowing through the loop
- A is the area of the loop
- B is the strength of the magnetic field
- θ is the angle between the magnetic field and the normal to the loop

From the formula, we can see that the torque is directly proportional to:

- **N (number of turns):** More turns mean more current loops, leading to a larger torque.
- **I (current):** Higher current results in stronger magnetic moments and thus greater torque.
- **A (area):** A larger loop area creates a larger magnetic dipole moment, leading to a larger torque.
- **B (magnetic field strength):** A stronger magnetic field exerts a greater force on the current, resulting in more torque.

However, the formula does not explicitly include the shape of the loop. The shape affects the loop's magnetic moment, but ultimately, the torque depends on the **area** of the loop, not its specific shape.

Let's consider an example. Imagine two loops: one square and one circular, both with the same area. Even though they have different shapes, they will experience the same torque in the same magnetic field because their areas are equal.

Therefore, the torque acting on a current-carrying loop in a uniform magnetic field does not depend on the shape of the loop.

Question110

Two long conductors, separated by a distance 'd' carry currents 'I_1' and 'I_2' in the same directions. They exert a force 'F' on each other. Now the current in one of them is increased to two times and its direction is reversed. The distance is also increased to '3 d'. The new value of the force between them is

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Options:

A. $-2\ \mathrm{F}$

B. $-\mathrm{F}$

C. $-\frac{2\ \mathrm{F}}{3}$

D. $\frac{\mathrm{F}}{3}$

Answer: C

Solution:

Force on each conductor is given by

$\mathrm{F}=\frac{\mu_0}{4 \pi} \cdot \frac{2 \mathrm{I}_1 \mathrm{I}_2}{\mathrm{~d}} \cdot \ell$

The force will be attractive. If the direction of current is reversed in one conductor the force will become repulsive.

$\therefore F^{\prime}=-\frac{\mu_0}{4 \pi} \cdot \frac{2 I_1 I_2}{3 d} \cdot \ell=-\frac{2}{3} F$

Question111

An electron in a circular orbit of radius $0.05\ \mathrm{nm}$ performs 10^{14} revolutions/second. What is the magnetic moment due to the rotation of electron? $\left(\mathrm{e}=1.6 \times 10^{-19} \mathrm{C}\right)$

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Options:

A. 3.21×10^{-23}

B. 2.16×10^{-23}

C. 3.21×10^{-22}

D. 1.26×10^{-28}

Answer: D

Solution:

$$\begin{aligned} r &= 0.05 \text{ nm} = 0.05 \times 10^{-9} \text{ m} = 5 \times 10^{-11} \text{ m} \\ f &= 10^{16} \text{ r.p.s} \\ M &= IA = ef\pi r^2 \\ &= 1.6 \times 10^{-19} \times 10^{16} \times 3.14 \times \left(5 \times 10^{-11}\right)^2 \\ &= 1.26 \times 10^{-23} \text{ A} - \text{m}^2 \end{aligned}$$

Question112

A long solenoid carrying current I_1 produces magnetic field B_1 along its axis. If the current is reduced to 20% and number of turns per cm are increased five times then new magnetic field B_2 is equal to

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Options:

A. B_1

B. $\frac{B_1}{5}$

C. $5B_1$

D. $0.25B_1$

Answer: A

Solution:

Let's analyze the given problem systematically. The magnetic field inside a long solenoid is determined by the formula:

$B = \mu_0 n I$

where:

- μ_0 is the permeability of free space,

- n is the number of turns per unit length,

- I is the current passing through the solenoid.

Initially, the solenoid produces a magnetic field given by:

$B_1 = \mu_0 n_1 I_1$

When the current is reduced to 20% of its original value, the new current becomes:

$I_2 = 0.20 I_1$

Additionally, if the number of turns per centimeter is increased five times, the new number of turns per unit length becomes:

$n_2 = 5n_1$

Now, using the formula for the magnetic field in a solenoid, the new magnetic field B_2 can be calculated as:

$B_2 = \mu_0 n_2 I_2$

Substitute the values of n_2 and I_2 into the equation:

$B_2 = \mu_0 (5n_1)(0.20 I_1)$

Simplifying this, we get:

$B_2 = \mu_0 \cdot 5n_1 \cdot 0.20 I_1$

$B_2 = \mu_0 n_1 I_1 \cdot 1.0$

$B_2 = B_1$

Therefore, the new magnetic field B_2 is equal to the original magnetic field B_1. Hence, the correct answer is:

Option A: B_1

Question113

A straight wire of diameter $0.4 \mathrm{~mm}$ carrying a current of $2 \mathrm{~A}$ is replaced by another wire of 0.8 mm diameter carrying the same current. The magnetic field at distance (R) from both the wires is 'B_1' and 'B_2' respectively. The relation between B_1 and B_2 is

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Options:

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

B. $B_1 = B_2$

C. $\mathrm{B}_1 = 2\,\mathrm{B}_2$

D. $\mathrm{B}_1 = \frac{\mathrm{B}_2}{3}$

Answer: B

Solution:

Since the some current flows through the second wire, the magnetic field at the same distance will be same.
$\therefore B_1 = B_2$

Question114

An electron is projected along the axis of circular conductor carrying current 'I' The electron will experience

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Options:

A. a force perpendicular to axis

B. a force along the axis

C. a force at angle 30° with the axis

D. no force

Answer: D

Solution:

The direction of the magnetic field will be along the axis. The angle between the velocity and the magnetic field will be 0° or 180°. The force is given by $\mathrm{F} = \mathrm{qvB}\sin\theta$

If $\theta = 0^\circ$ or $180^\circ, \mathrm{F} = 0$

Question115

A thin ring of radius 'R' meter has charge 'q' coulomb uniformly spread on it. The ring rotates about its axis with a constant frequency of f revolution/s. The value of magnetic induction in Wbm^{-2} at the center of the ring is(μ_0 = Permeability of free space)

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Options:

A. $\frac{\mu_0 \mathrm{qf}}{2\pi \mathrm{R}}$

B. $\frac{\mu_0 q}{2\pi R}$

C. $\frac{\mu_0 q f}{2R}$

D. $\frac{\mu_0 q}{2\pi f R}$

Answer: C

Solution:

To solve this problem, we need to compute the magnetic field (magnetic induction) at the center of the rotating ring due to the current created by the moving charges. Here's a step-by-step explanation:

Step 1: Determine the current (I) created by the rotating charges.

Since the ring has a charge q uniformly spread on it and it rotates with a frequency f revolutions per second, each charge completes one full revolution every $1/f$ seconds. The ring's rotation creates a circular current I.

The formula for the current due to the rotation of charges is:

$I = q \cdot f$

Step 2: Use the Biot-Savart law to find the magnetic field at the center of the ring.

For a circular loop, the magnetic field at the center is given by:

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

Substituting the current I from step 1 into this equation, we have:

$B = \frac{\mu_0 (q \cdot f)}{2R}$

Thus, the magnetic induction at the center of the ring is:

$B = \frac{\mu_0 q f}{2R}$

Conclusion:

The correct answer is:

Option C

$\frac{\mu_0 q f}{2R}$

Question116

A particle having a charge $100\mathrm{e}$ is revolving in a circular path of radius $0.8 \mathrm{~m}$ with 1. r.p.s The magnetic field produced at the centre of the circle in SI unit is $(\mu_0 =$ permeability of vacuum, $e=1.6 \times 10^{-19} \mathrm{C})$

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Options:

A. $10^{-17} \mu_0$

B. $10^{-3} \mu_0$

C. $10^{-7} \mu_0$

D. $10^{-11} \mu_0$

Answer: A

Solution:

To find the magnetic field produced at the center of the circular path by a revolving charge, we can use the expression derived from Biot-Savart law for a moving charge. The magnetic field B at the center of a circular loop carrying a steady current I is given by:

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

However, in this scenario, we don't have a steady current but a charged particle moving in a circular path. The equivalent "current" in this situation is the charge passing a point per unit time. Since the particle completes one revolution per second (1 r.p.s), it's equivalent to having a current where the charge Q passes the point of observation once per second. Therefore, the equivalent current I is the charge divided by the time period T of one revolution, which is 1 second here:

$I=\frac{Q}{T}=\frac{100e}{1\text{ s}}=\frac{100\times1.6\times10^{-19}\text{ C}}{1\text{ s}}=1.6\times10^{-17}\text{ A}$

Given the radius $R=0.8\text{ m}$ and substituting the values into the equation for B:

$B=\frac{\mu_0 I}{2R}=\frac{\mu_0\times1.6\times10^{-17}}{2\times0.8}$

Simplifying this:

$B=\frac{\mu_0\times1.6\times10^{-17}}{1.6}=\mu_0\times10^{-17}$

Therefore, the magnetic field produced at the center of the circle in SI unit is:

$10^{-17}\mu_0$

Which corresponds to **Option A**.

Question117

The magnetic field inside a current carrying toroidal solenoid is 0.2 mT. What is the magnetic field inside the toroid if the current through it is tripled and radius is made $\frac{1}{3}^{\text{rd}}$?

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Options:

A. 0.2 mT

B. 0.6 mT

C. 0.8 mT

D. 0.9 mT

Answer: B

Solution:

Magnetic field inside the toroid is given by

$$B=\mu_0 nI$$
$$\therefore\frac{B_2}{B_1}=\frac{I_2}{I_1}=3$$

(If cross-sectional radius of the solenoid is changed there will be no effect on the magnetic field, assuming the number of turns remains same.)

$\therefore B_2 = 3B_1 = 3 \times 0.2 = 0.6$ T

Question118

When a battery is connected to the two ends of a diagonal of a square conductor frame of side 'a', the magnitude of magnetic field at the centre will be ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0}{\sqrt{2}\pi a}$

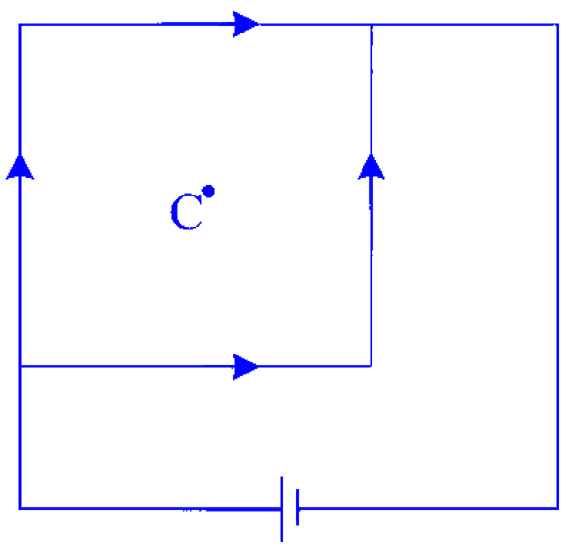
B. $\frac{\sqrt{2}\mu_0}{\pi a}$

C. $\frac{\mu_0}{\pi a}$

D. zero

Answer: D

Solution:



As shown in the figure, the currents in the parallel sides will produce equal and opposite fields at the centre and hence the net magnetic field at the centre will be zero.

Question119

Two concentric coplanar circular loops of radii 'r_1' and 'r_2' respectively carry currents 'i_1' and 'i$_2$' in opposite directions (one clockwise and other anticlockwise). The magnetic induction at the centre of the loops is half that due to 'i_1' alone at the centre. If $r_2 = 2r_1$, the value of $\frac{i_2}{i_1}$

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Options:

A. $\frac{1}{4}$

B. 1

C. 2

D. $\frac{1}{2}$

Answer: B

Solution:

To solve this problem, let's use the formula for the magnetic field at the center of a circular loop due to a current flowing through it. The magnetic field at the center of a loop due to a current is given by:

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

where μ_0 is the permeability of free space, i is the current, and r is the radius of the loop.

Let's designate the two loops as follows:

- Loop 1: Radius = r_1, Current = i_1 (clockwise)
- Loop 2: Radius = r_2, Current = i_2 (anticlockwise)

The magnetic field at the center due to Loop 1 is:

$B_1 = \frac{\mu_0 i_1}{2r_1}$

The magnetic field at the center due to Loop 2 is:

$B_2 = \frac{\mu_0 i_2}{2 r_2}$

Since the currents flow in opposite directions, the magnetic fields they produce at the center will be in opposite directions. We are given that the net magnetic field at the center is half of the magnetic field due to i_1 alone:

$B_{\text{net}} = \frac{1}{2} B_1 = \frac{\mu_0 i_1}{4 r_1}$

Therefore, the net magnetic field can be written as the difference between the magnetic fields produced by the two loops:

$B_{\text{net}} = B_1 - B_2$

Substituting the given values:

$\frac{\mu_0 i_1}{4 r_1} = \frac{\mu_0 i_1}{2 r_1} - \frac{\mu_0 i_2}{2 r_2}$

We are also given that $r_2 = 2 r_1$. Substituting this into the equation:

$\frac{\mu_0 i_1}{4 r_1} = \frac{\mu_0 i_1}{2 r_1} - \frac{\mu_0 i_2}{2 \cdot 2 r_1}$

Simplifying this, we get:

$\frac{\mu_0 i_1}{4 r_1} = \frac{\mu_0 i_1}{2 r_1} - \frac{\mu_0 i_2}{4 r_1}$

Multiplying through by $4 r_1 / \mu_0$ to clear the denominators:

$i_1 = 2 i_1 - i_2$

Rearranging to solve for i_2:

$i_2 = 2 i_1 - i_1 = i_1$

Hence,

$\frac{i_2}{i_1} = 1$

Therefore, the correct answer is Option B: 1

Question120

Assuming the atom is in the ground state, the expression for the magnetic field at a point nucleus in hydrogen atom due to circular motion of electron is [μ_0 = permeability of free space, m = mass of electron, ϵ_0 = permittivity of free space, h = Planck's constant]

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Options:

A. $\frac{\mu_0 e^7 \pi m^2}{8 \in_0^3 h^5}$

B. $\frac{\mu_0 e^5 \pi m^3}{8 \epsilon_0^3 h^5}$

C. $\frac{\mu_0 e^5 \pi^2 m^2}{8 \epsilon_0^2 h^4}$

D. $\frac{\mu_0 e^7 \pi^2 m^2}{8 \epsilon_0^3 h^5}$

Answer: A

Solution:

The magnetic field at the centre of a circular coil is given by

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

If T is the periodic time of revolving electron, then $I = \frac{e}{T}$

Also, $T = \frac{2\pi r}{V}$

$\therefore \quad I = \frac{eV}{2\pi r}$

$\therefore \quad B = \frac{\mu_0 eV}{4\pi r^2} \quad ....(1)$

For electron in ground state,

$V = \frac{e^2}{2\epsilon_0 h}$ and $r = \frac{h^2 \epsilon_0}{\pi m e^2}$

Putting these values in eq. (1) and simplifying we get

$\therefore B = \frac{\mu_0 e^7 \pi m^2}{8 \epsilon_0 h^5}$

Question121

A, B and C are three parallel conductors of equal lengths carrying currents I, I and $2\mathrm{I}$ respectively. Distance between A and B is 'x' and that between B and C is also 'x'. F_1 is the force exerted by conductor B on A. F_2 is the force exerted by conductor C on A. Current I in A and I in B are in same direction and current $2\mathrm{I}$ in C is in opposite direction. Then

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Options:

A. $\mathrm{F}_1=\mathrm{F}_2$

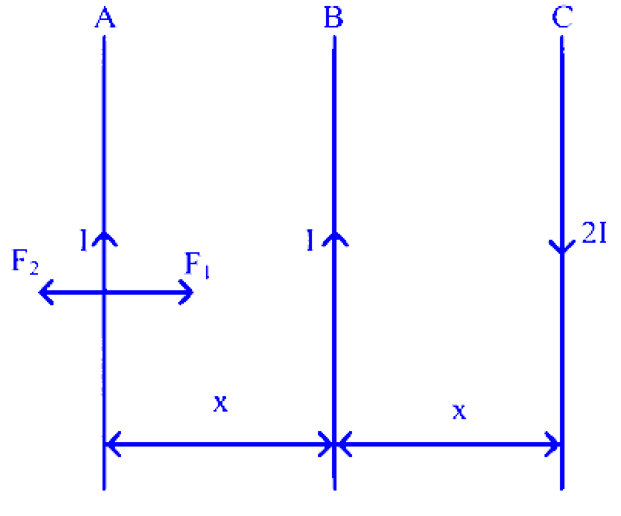
B. $\mathrm{F}_2=2\mathrm{R}_1$

C. $F_1=2R_2$

D. $F_1=-F_2$

Answer: D

Solution:



Currents in A and B are in the same direction. Hence force F_1 exerted by B on A will attractive (towards B). Current in A and C are in opposite directions. Hence force F_2, exentos by C on A will be repulsive (away from C). Thus F_1 and F_2 are opposite in direction.

$$F_1=\frac{\mu_0}{2\pi}\cdot\frac{I_1 I_2}{x}\cdot L=\frac{\mu_0}{2\pi}\cdot\frac{I^2}{x}\cdot L$$
$$F_2=\frac{\mu_0}{2\pi}\cdot\frac{2I^2}{2x}\cdot L=\frac{\mu_0}{2\pi}\cdot\frac{I^2}{x}\cdot L$$

$\therefore F_1$ and F_2 have some magnitude.

$\therefore \mathrm{F}_1=-\mathrm{F}_2$

Question122

Magnetic moment of revolving electron of charge (e) and mass (m) in terms of angular momentum (L) of electron is :

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Options:

A. $\frac{eL}{8m}$

B. $\frac{\mathrm{eL}}{4\ \mathrm{m}}$

C. $\frac{\mathrm{eL}}{2\ \mathrm{m}}$

D. $\frac{\mathrm{eL}}{\mathrm{m}}$

Answer: C

Solution:

The magnetic moment μ associated with the angular momentum L of a revolving electron is given by :

$\mu=\frac{-e}{2m}L$

The negative sign indicates the direction of the magnetic moment is opposite to the direction of angular momentum. However, for the sake of magnitude, we'll focus on :

$\mu=\frac{eL}{2m}$

So, the correct answer is Option C : $\frac{eL}{2m}$.

Question123

The magnetic flux near the axis and inside the air core solenoid of length $60 \mathrm{~cm}$ carrying current 'I' is $1.57 \times 10^{-6} \mathrm{~Wb}$. Its magnetic moment will be $\left[\mu_0=4 \pi \times 10^{-7}\right.$, SI unit and crosssectional area is very small as compared to length of solenoid.]

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Options:

A. $1 \mathrm{~Am}^2$

B. $0.25 \mathrm{~Am}^2$

C. $0.5 \mathrm{~Am}^2$

D. $0.75 \mathrm{~Am}^2$

Answer: D

Solution:

Magnetic field inside the solenoid is given by

$$B=\frac{\mu_0 \mathrm{NI}}{\mathrm{L}}$$

$$\therefore \frac{\phi}{\mathrm{A}}=\frac{\mu_0 \mathrm{NI}}{\mathrm{L}}$$

$$\begin{aligned}
\therefore \text{ Magnetic moment, NIA } & =\frac{\phi \mathrm{L}}{\mu_0} \\
& =\frac{1.5 \times 10^{-6} \times 0.6}{4 \times 3.14 \times 10^{-7}} \\
& =0.75 \mathrm{Am}^2
\end{aligned}$$

Question124

A charge moves with velocity 'V' through electric field (E) as well as magnetic field (B). then the force acting on it is

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Options:

A. $q(\vec{B} \times \vec{V})$

B. $\mathrm{q}(\overrightarrow{\mathrm{V}} \times \overrightarrow{\mathrm{B}})$

C. $q \overrightarrow{\mathrm{E}}+q(\vec{V} \times \vec{B})$

D. $q(\vec{E} \times \vec{V})$

Answer: C

Solution:

Force due to electric field $\vec{F}_e=q \vec{E}$

Force due to magnetic field $\overrightarrow{\mathrm{F}}_{\mathrm{m}}=\mathrm{q}(\overrightarrow{\mathrm{v}} \times \overrightarrow{\mathrm{B}})$

$\therefore$ Total force $\overrightarrow{\mathrm{F}}=\mathrm{q} \overrightarrow{\mathrm{E}}+\mathrm{q}(\overrightarrow{\mathrm{v}} \times \overrightarrow{\mathrm{B}})$

Question125

A long solenoid carrying a current produces a magnetic field B along its axis. If the number of turns per cm is doubled and the current is made $\left(\frac{1}{3}\right)^{\text{rd}}$ then the new value of the magnetic field will be

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Options:

A. $\frac{B}{3}$

B. 3B

C. 2 B

D. $\frac{2\text{ B}}{3}$

Answer: D

Solution:

Magnetic field inside a solenoid is given by

$\mathrm{B}=\mu_0 \mathrm{nI}$

If n is doubled and I is made $\left(\frac{1}{3}\right)^{\text{rd}}$, the value of B will become $\frac{2}{3}$ B.

Question126

A metal conductor of length $1 \mathrm{~m}$ rotates vertically about one of its ends at an angular velocity of $5 \mathrm{rad} / \mathrm{s}$. If horizontal component of earth's magnetic field is $0.2 \times 10^{-4} \mathrm{~T}$, then the e.m.f. developed between the two ends of the conductor is

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Options:

A. $5 \mu \mathrm{V}$

B. 50 mV

C. 5 mV

D. 50 μV

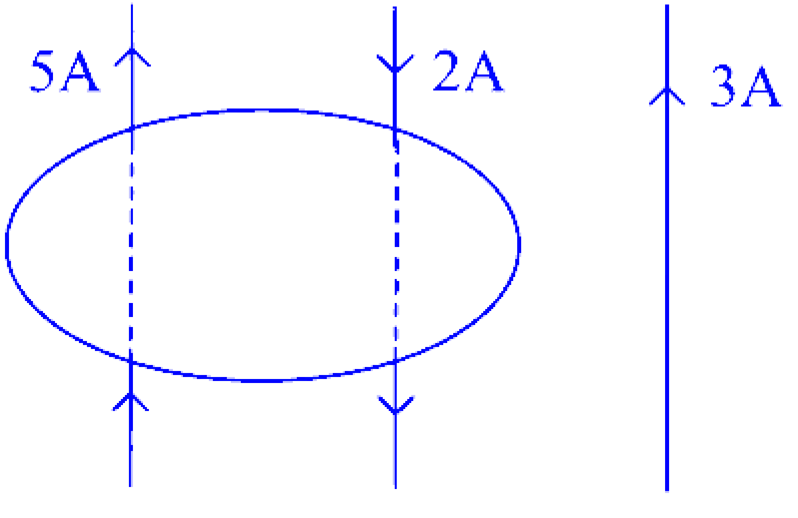
Answer: D

Solution:

$$\begin{aligned} \text{EMF, e} &= \pi r^2 Bf \quad = \pi r^2 B \tfrac{\omega}{2\pi} \quad = \tfrac{1}{2} Br^2 \omega \\ &= \tfrac{1}{2} \times 0.2 \times 10^{-4} \times (1)^2 \times 5 \\ &= 0.5 \times 10^{-4}\ \text{V} \qquad = 50 \mu\text{V} \end{aligned}$$

Question127

Two wires carrying currents 5 A and 2 A are enclosed in a circular loop as shown in the figure. Another wire carrying a current of 3 A is situated outside the loop. The value of $\oint \overrightarrow{B} d\vec{l}$ around the loop is ($\mu_0 =$ permeability of free space, $\overrightarrow{dl}$ is the length of the element on the Amperion loop)



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Options:

A. $4\mu_0$

B. $2\mu_0$

C. $3\mu_0$

D. μ_0

Answer: C

Solution:

Current of 5 A and 2 A are enclosed in the loop.

The currents are in opposite direction.

The net current enclosed by the loop is 3 A.

According to Ampere law,

$$\oint \overrightarrow{\mathrm{B}} \overrightarrow{\mathrm{di}}=\mu_0 \mathrm{I}=3 \mu_0$$

Question128

The magnetic field at the centre of a current carrying circular coil of area 'A' is 'B'. The magnetic moment of the coil is ($\mu_0 =$ permeability of free space)

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Options:

A. $\frac{2 \mathrm{BA}^{3/2}}{\mu_0 \sqrt{\pi}}$

B. $\frac{\mathrm{BA}^{3/2}}{\mu_0 \pi}$

C. $\frac{\mu_0 \sqrt{\pi}}{2 \mathrm{BA}^2}$

D. $\frac{2 \mathrm{BA}^2}{\mu_0 \sqrt{\pi}}$

Answer: A

Solution:

☆ Step 1: Magnetic field at centre of a current loop

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

☆ Step 2: Relate radius R to area A

$$A = \pi R^2$$

$$R = \sqrt{\frac{A}{\pi}}$$

☆ Step 3: Substitute R in the magnetic field formula

$$B = \frac{\mu_0 I}{2\sqrt{A/\pi}}$$

$$B = \frac{\mu_0 I}{2} \cdot \frac{\sqrt{\pi}}{\sqrt{A}}$$

Solve for current I:

$$I = \frac{2B\sqrt{A}}{\mu_0\sqrt{\pi}}$$

☆ Step 4: Magnetic moment of a loop

$$M = IA$$

Substitute I:

$$M = A \cdot \frac{2B\sqrt{A}}{\mu_0\sqrt{\pi}}$$

Combine $A \cdot \sqrt{A} = A^{3/2}$:

$$\boxed{M = \frac{2BA^{3/2}}{\mu_0\sqrt{\pi}}}$$

Question129

The relation between magnetic moment 'M' of revolving electron and principle quantum number 'n' is

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Options:

A. M $\propto \frac{1}{n}$

B. $M \propto n$

C. $M \propto n^2$

D. $M \propto \mathrm{n}^3$

Answer: B

Solution:

✅ Correct Answer: B. $M \propto n$

✔ **Explanation (Bohr Model + Magnetic Moment)**

For an electron revolving in the n^{th} Bohr orbit:

1 **Magnetic moment of an orbiting electron:**

$$M = IA$$

2 **Angular momentum is quantized:**

$$L = mvr = n\hbar$$

3 **Bohr magneton relation:**

$$M = \frac{e}{2m}L$$

Substitute $L = n\hbar$:

$$M = \frac{e}{2m}(n\hbar)$$

Thus,

$$\boxed{M \propto n}$$

Question130

If the charge to ratio of an electron is 'A' C/kg, then the gyromagnetic ratio of an orbital electron in C/kg is

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Options:

A. $\frac{A}{4}$

B. A

C. 2A

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

Answer: D

Solution:

Gyromagnetic ratio $= \frac{e}{2m_e} = \frac{A}{2}$

Question131

The magnetic field intensity 'H' at the centre of a long solenoid having 'n' turns per unit length and carrying a current 'I', when no material is kept in it, is

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Options:

A. $\frac{1}{n}$

B. $\frac{n}{1}$

C. nI

D. n^2I

Answer: C

Solution:

The magnetic field

$B = \mu_0 H$

For a solenoid $B = \mu_0 nI$

$\therefore H = nI$

Question132

An electron (e) moves in circular orbit of radius 'r' with uniform speed 'V'. It produces magnetic field 'B' at the centre of circle. The magnetic field B is $(\mu_0 =$ permeability of free space)

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Options:

A. $\frac{\mu_0 e}{4\pi}\left(\frac{V}{r^2}\right)$

B. $\frac{\mu_0 e}{4\pi} V r^2$

C. $\frac{\mu_0 e}{4\pi}\left(\frac{V}{r}\right)$

D. $\frac{\mu_0 e}{4\pi} V r$

Answer: A

Solution:

Magnetic field at the centre of a circular coil is given by

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

In this case the current $I = \frac{e}{T}$ where T is the period of revolution

$$T = \frac{2\pi r}{v}$$

$$\therefore I = \frac{eV}{2\pi r} \quad \therefore \quad B = \frac{\mu_0 eV}{4\pi r^2}$$

Question133

An electron moves in a circular orbit with uniform speed v. It produces a magnetic field B at the centre of the circle. The radius of the circle is [μ_0 = permeability of free space, e = electronic charge]

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Options:

A. $\left(\frac{\mu_0 ev}{4\pi B}\right)^{1/2}$

B. $\frac{\mu_0 eB}{4\pi v}$

C. $\frac{\mu_0 eV}{4\pi B}$

D. $\left(\frac{\mu_0 ev}{B}\right)^{1/2}$

Answer: A

Solution:

The magnetic field at the centre of a circular orbit of a moving electron is given by

$$B = \frac{\mu_0}{4\pi} \times \frac{e}{r^3}(\mathbf{v} \times \mathbf{r})$$

$$B = \frac{\mu_0}{4\pi} \times \frac{ev\sin\theta}{r^2}$$

As, in a circular path, the angle between radius vector and velocity vector is 90°.

$$\Rightarrow \quad B = \frac{\mu_0}{4\pi} \times \frac{\theta V}{r^2}$$

$$\therefore \quad r = \left(\frac{\mu_0 ev}{4\pi B}\right)^{1/2}$$

Question134

A circular coil of radius R is carrying a current I_1 in anti-clockwise sense. A long straight wire is carrying current I_2 in the negative direction of X-axis. Both are placed in the same plane and the distance between centre of coil and straight wire is d. The magnetic field at the centre of coil will be zero for the value of d equal to

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Options:

A. $\frac{R}{\pi}\left(\frac{l_2}{l_1}\right)$

B. $\frac{\pi}{R}\left(\frac{l_2}{l_1}\right)$

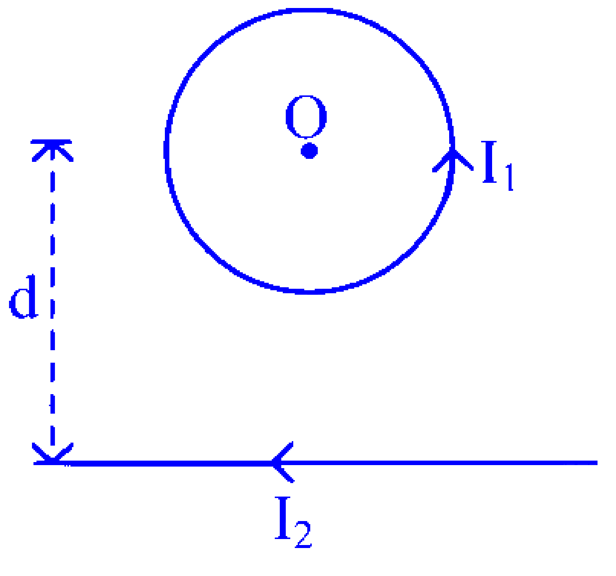
C. $\frac{\pi}{R}\left(\frac{l_1}{l_2}\right)$

D. $\frac{R}{\pi}\left(\frac{l_1}{l_2}\right)$

Answer: A

Solution:

Consider the figure shown below,



The magnetic field due to the circular coil at its centre is given by

$B_1 = \frac{\mu_0 I_1}{2R}$ (outward)

The magnetic field due to the wire at O is given by

$$B_2 = \frac{\mu_0 I_2}{2\pi d}$$

The net magnetic field at the centre of coil is zero.

$$\therefore \quad B_1 - B_2 = 0$$

$$\frac{\mu_0 I_1}{2R} - \frac{\mu_0 I_2}{2\pi d} = 0$$

$$d = \left(\frac{I_2}{I_1}\right)\frac{R}{\pi}$$

Question135

An α-particle of energy 10 eV is moving in a circular path in uniform magnetic field. The energy of proton moving in the same path and same magnetic field will be [mass of α-particle $= 4$ times mass of proton]

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Options:

A. 8 eV

B. 16 eV

C. 4 eV

D. 10 eV

Answer: D

Solution:

The radius of circular path of charged particlein uniform magnetic field,

$R = \frac{mv}{qB}$ .... (i)

The kinetic energy of charged particle,

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

$$\Rightarrow \quad v = \sqrt{\frac{2K}{m}} \quad .... \text{(ii)}$$

Substituting Eq. (ii) in Eq. (i), we get

$$R = \frac{m\sqrt{\frac{2K}{m}}}{qB} = \frac{\sqrt{2mK}}{qB}$$

For proton,

$$R_p = \frac{\sqrt{2m_pK_p}}{q_pB} \quad .... \text{(iii)}$$

where, mass of proton is m_p, kinetic energy of proton is K_p and charge on proton is q_p.

Similarly, for α-particle,

$$R_\alpha = \frac{\sqrt{2m_\alpha K_\alpha}}{q_\alpha B} \quad .... \text{(iv)}$$

where, mass of α-particle is m_α, charge on α-particle is q_α and kinetic energy of α-particle is K_α.

Here, $m_a = 4m_p$ and $q_a = 2q_p$ Substituting value in Eq. (iv), we get

$$R_a = \frac{\sqrt{2(4m_p)K_a}}{B(2q_p)} = \frac{\sqrt{2m_pK_a}}{Bq_p}$$

$$\therefore \quad \frac{R_p}{R_\alpha} = \sqrt{\frac{K_p}{K_\alpha}}$$

$$\text{As, } R_p = R_\alpha \quad \text{(given)}$$

$$\therefore \quad K_\alpha = K_p = 10\text{eV}$$

Question136

An electron (e) is revolving in a circular orbit of radius r in hydrogen atom. The angular momentum of the electron is ($M =$ magnetic dipole moment associated with it and $m =$ mass of electron)

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Options:

A. $\frac{mM}{e}$

B. $\frac{3Mm}{e}$

C. $\frac{2mM}{e}$

D. $\frac{4mM}{e}$

Answer: C

Solution:

To address this question, we need to look at the relationship between the angular momentum of an electron in a hydrogen atom, its magnetic dipole moment, and other physical constants. The angular momentum (L) of an electron revolving in a circular orbit in a hydrogen atom is quantized and is given by the formula:

$L = n\frac{h}{2\pi}$

where n is the principal quantum number (which is any positive integer), and h is Planck's constant. The magnetic dipole moment (M) of a revolving electron is related to its angular momentum by the formula:

$M = \frac{eL}{2m}$

By substituting the expression for L into the formula for M, we get:

$M = \frac{e \times n\frac{h}{2\pi}}{2m}$

Now, if we solve the expression for L in terms of M, m, and e, we rearrange the formula to get L as:

$L = \frac{2mM}{e}$

Therefore, the correct answer to the question is Option C, which states that the angular momentum of the electron is given by:

$\frac{2mM}{e}$

Question137

A charged particle is moving in a uniform magnetic field in a circular path of radius R. When the energy of the particle becomes three times the original, the new radius will be

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Options:

A. R

B. $\sqrt{3}R$

C. $3R$

D. $\frac{R}{3}$

Answer: B

Solution:

The radius of the circular path of a charged particle moving in a uniform magnetic field depends on the particle's velocity, the charge of the particle, and the strength of the magnetic field. The formula for the radius R of the path is given by:

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

where:

- m is the mass of the particle,
- v is the velocity of the particle,
- q is the charge of the particle, and
- B is the magnetic flux density of the magnetic field.

For the energy of the charged particle, we use the kinetic energy formula since the only energy the charged particle has in a magnetic field is due to its motion:

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

When the energy of the particle becomes three times the original, we can represent this new energy as:

$3KE = 3 \times \frac{1}{2}mv^2 = \frac{3}{2}mv^2$

To find the new velocity, we set this equal to the kinetic energy formula and solve for v:

$\frac{3}{2}mv^2 = \frac{1}{2}m(v')^2$

Here, v' represents the new velocity. Solving for v' gives us:

$v' = \sqrt{3}v$

Finally, substituting this new velocity into the original formula for the radius, we have:

$R' = \frac{m(\sqrt{3}v)}{qB} = \sqrt{3} \times \frac{mv}{qB} = \sqrt{3}R$

Therefore, the new radius is $\sqrt{3}R$. Hence, the correct option is:

Option B

$\sqrt{3}R$

Question138

A charge q moves with velocity v through electric field E as well as magnetic field (B). Then, the force acting on it is

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Options:

A. $q(E \times v)$

B. $q(B \times v)$

C. $qE + q(v \times B)$

D. $q(v \times B)$

Answer: C

Solution:

The force on a charge q due to electric field is

$F_E = qE \quad$ ..... (i)

and due to magnetic field is

$\mathrm{F}_B = q(\mathrm{v} \times \mathrm{B})$

When charge particle moves in combined field,

Resultant force,

$$\begin{aligned} \mathbf{F} &= \mathbf{F}_E + \mathbf{F}_B \\ &= q\mathbf{E} + q(\mathbf{v} \times \mathbf{B}) \end{aligned}$$

Question139

Maximum kinetic energy gained by the charged particle in the cyclotron is independent of

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Options:

A. radius of the dees

B. charge

C. mass

D. frequency of revolution

Answer: D

Solution:

Maximum kinetic energy gained by charged particle in a cyclotion is given by

$E_K = \frac{q^2B^2R^2}{2m}$

where, $q =$ charge of the cyclotron,

$B =$ intensity of magnetic field,

$R =$ radius of orbit

and $m =$ mass of the particle,

Hence, E_K is independent of frequency of revolution.

Question140

In a hydrogen atom, an electron of charge e revolves in a orbit of radius r with speed v. Then, magnetic moment associated with electron is

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Options:

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

B. 2 evr

C. evr

D. $\frac{evr}{3}$

Answer: A

Solution:

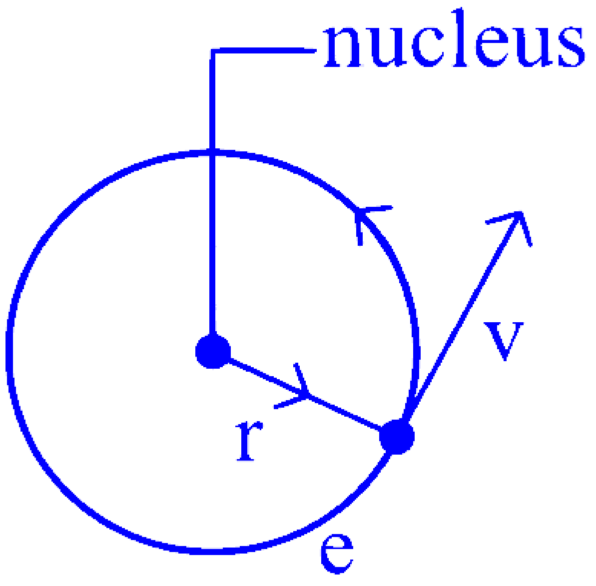
Magnetic moment of revolving electron,

$\mu_e = i \times \mathbf{A}$

where, $i =$ current and $A =$ area,

$\therefore \quad \mu_e = \frac{e}{T} \times \pi r^2 \quad$ (As current, $i = \frac{\text{charge}}{\text{time}} = \frac{e}{T}$)

where, T = time period of revolution and r = radius of orbit.



$\mu_e = \frac{e}{2\pi r} \times v \times \pi r^2$

$\left(\because \text{ Time period } (T) = \frac{\text{distance}}{\text{speed}}\right)$

where, $\mathbf{v} =$ velocity of revolving electron

$\Rightarrow \quad \mu_e = \frac{evr}{2}$

Hence, the magnetic moment of revolving electron is $\frac{evr}{2}$.

Question141

Six very long insulated copper wires are bound together to form a cable. The currents carried by the wires are $I_1 = +10$ A, $I_2 = -13$ A, $I_3 = +10$ A, $I_4 = +7$ A, $I_5 = -12$ A and $I_6 = +18$ A. The magnetic induction at a perpendicular distance of 10 cm from the cable is $\left(\mu_0 = 4\pi \times 10^{-7} \text{ Wb/A} - \text{m}\right)$

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Options:

A. 40μ T

B. 37.5μ T

C. 30μ T

D. 35μ T

Answer: A

Solution:

Net current due to all wires,

$$\begin{aligned} i_{\text{net}} &= i_1 + i_2 + i_3 + i_4 + i_5 + i_6 \\ i_{\text{net}} &= 10 - 13 + 10 + 7 - 12 + 18 = 20 \text{ A} \end{aligned}$$

We know, magnetic field due to an infinitely long straight conductor at a perpendicular distance r from it is given by

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

where, $i =$ current in wire

and $r =$ perpendicular distance.

$$= \frac{4\pi \times 10^{-7} \times 20}{2\pi \times 10 \times 10^{-2}} = 4 \times 10^{-5}$$
$B = 40\mu$ T

Question142

A circular coil and a square coil is prepared from two identical metal wires and a current is passed through it. Ratio of magnetic dipole moment associated with circular coil to that of square coil is

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Options:

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

B. $\frac{\pi}{2}$

C. π

D. $\frac{4}{\pi}$

Answer: D

Solution:

Let / be the length of metal wire.

When wire is bent into a circular coil of radius r, then

$$r = \frac{1}{2\pi}$$

$\therefore$ Area, $\quad A = \pi\left(\frac{1}{2\pi}\right)^2 = \pi\frac{l^2}{4\pi^2}$

$\therefore$ Magnetic dipole moment associated with circular coil,

$$\mu_c = iA = i\pi\left(\frac{l^2}{4\pi^2}\right)$$

$$\mu_c = \frac{iI^2}{4\pi} \quad \text{.... (i)}$$

When metal wire is bent into a square coil then side of square

$a=\frac{I}{4}$

$\therefore$ Area, $\quad A=a^2=\frac{1^2}{16}$

$\therefore$ Magnetic dipole moment associated with square coil,

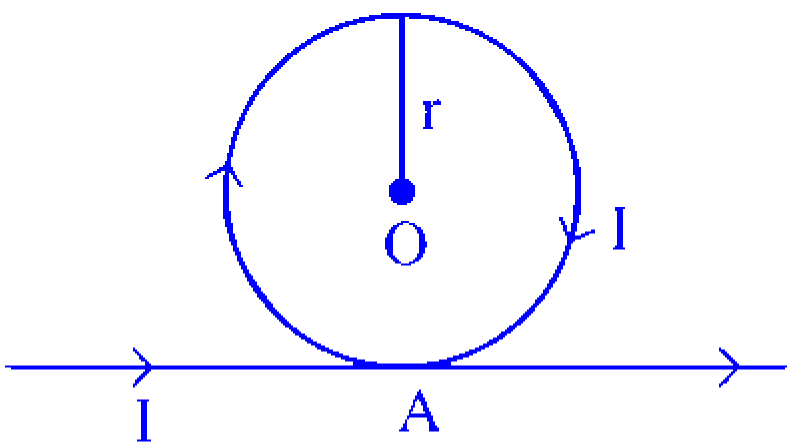
$$\mu_s=iA=i\frac{l^2}{16}$$

$$\therefore \quad \frac{\mu_C}{\mu_s}=\frac{\frac{il^2}{4\pi}}{\frac{1l^2}{16}}=\frac{16}{4\pi}=\frac{4}{\pi}$$

Hence, the ratio of magnetic dipole moment of circular coil and square coil is $4:\pi$.

Question143

Figure show the circular coil carrying current I kept very close but not touching at a point A on a straight conductor carrying the same current I. The magnitude of magnetic induction at the centre of the circular coil will be



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Options:

A. $\frac{\mu_0 0}{2r}\left(1+\frac{1}{\pi}\right)$

B. $\frac{\mu_0 l}{2\pi r}$

C. $\frac{\mu_0 l}{2r}$

D. zero

Answer: A

Solution:

✅ **Correct Answer: A — $\frac{\mu_0 I}{2r}\left(1+\frac{1}{\pi}\right)$**

Let's clearly understand why.

✔ Magnetic field at the centre comes from TWO sources:

1 The circular coil of radius r carrying current I

Magnetic field at centre of circular loop is:

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

---

2 The straight conductor carrying the same current I

The centre of the circle is at distance r from the straight wire (since point A is on the circumference and the centre is O).

Magnetic field due to a straight conductor at distance r:

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

✔ Total magnetic field at the centre

The directions of both fields are the same (from diagram), so they **add up**:

$$B_{\text{total}} = B_{\text{loop}} + B_{\text{wire}}$$

Substitute values:

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

Factor out $\frac{\mu_0 I}{2r}$:

$$\boxed{B_{\text{total}} = \frac{\mu_0 I}{2r}\left(1+\frac{1}{\pi}\right)}$$

Question144

Torque acting on a rectangular coil carrying current ' l ' situated parallel to magnetic field of induction ' B ', having number of turns ' n ' and area ' A ' is

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Options:

A. $ni(\hat{A} \cdot \hat{B})$

B. $\frac{nBA}{i}$

C. $ni(\mathbf{A} \times \mathbf{B})$

D. $\frac{iBA}{n}$

Answer: C

Solution:

When a current carrying coil is placed in a magnetic field, the coil experienced a torque given by

$\tau = \mathbf{M} \times \mathbf{B}$

where, $M =$ magnetic moment $= niA$

$\therefore \quad \tau = ni(\mathbf{A} \times \mathbf{B})$

where, $n =$ number of turns,

$i =$ current flowing in coil

and $A =$ area of coil

Question145

A circular coil of wire consisting of 100 turns each of radius 9 cm carries a current of 0.4 A . The magnitude of the magnetic field at the centre of coil is $\left[\mu_0 = 12.56 \times 10^{-7}\right.$SI Unit]

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Options:

A. 2.4×10^{-11} T

B. 2.79×10^{-5} T

C. 2.79×10^{-4} T

D. 2.79×10^{-3} T

Answer: C

Solution:

Given, number of turns, $n = 100$,

radius of coil, $r = 9 \text{ cm} = 9 \times 10^{-2}$ m

and current flow in the coil, $I = 0.4$ A

The magnitude of the magnetic field at the centre of a coil of n turns is given by

$B = \frac{\mu_0 n l}{2r}$ .... (i)

Substituting given values in Eq. (i), we get

$$\Rightarrow \quad B = \frac{1256 \times 10^{-7} \times 100 \times 0.4}{2 \times 10^{-1} \times 9 \times 10^{-2}}$$
$$= 2.79 \times 10^{-4} \text{ T}$$

Question146

The magnetic dipole moment of a short magnetic dipole at a distant point along the equator of magnet has a magnitude of ' X ' in SI units. If the distance between the point and the magnet is halved then the magnitude of dipole moment will be

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Options:

A. $2x$

B. $\frac{1}{2}x$

C. X

D. $\frac{1}{8}x$

Answer: C

Solution:

The magnetic dipole moment is the product of either of pole strength and the magnetic length of dipole. Thus, it is independent of the distance of point at which it is measured. So, it remains unchanged, if the distance between point and the magnet is halved.

Question147

Two parallel conductors carrying unequal currents in the same direction ....

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Options:

A. neither attract nor repel each other

B. repel each other

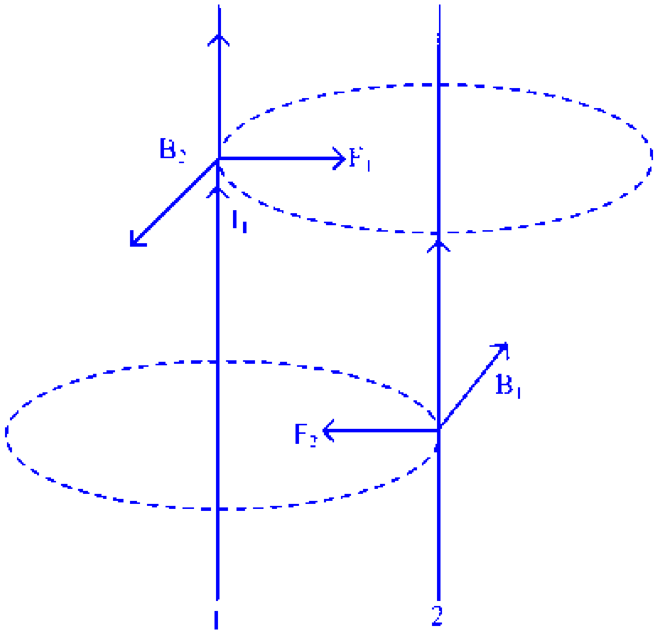
C. attract each other

D. will have rotational motion.

Answer: C

Solution:

Two wires 1 and 2 carrying currents i_1 and i_2 respectively are shown in the figure given below,



Force on wire 2 due to B_1 (field of wire 1) is given by

$F_2 = i_2 \mid B_1$

Using right hand screw rule, direction of F_2 would be towards wire 1.

Similarly, force on wire due to B_2 (field of wire 2)

$F_1 = i_1 / B_2$

Again, by using right hand screw rule, direction of F_1 would be towards wire 2.

If two parallel conductors carry (equal or unequal) current in the same direction, they will exerted force towards each other i.e., they will be attract each other.

Question148

The magnitude of the magnetic induction at a point on the axis at a large distance (r) from the centre of a circular coil of ' n ' turns and area ' A ' carrying current (I) is given by

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Options:

A. $B_{\text{axis}} = \frac{\mu_0}{4\pi} \cdot \frac{nA}{1r^3}$

B. $B_{\text{axis}} = \frac{\mu_0}{4\pi} \cdot \frac{2nlA}{r^3}$

C. $B_{\text{axis}} = \frac{\mu_0}{4\pi} \cdot \frac{2nl}{Ar^3}$

D. $B_{\text{axis}} = \frac{\mu_0}{4\pi} \cdot \frac{nlA}{r^3}$

Answer: B

Solution:

As we know that the magnetic field on the axis of a circular current carrying loop,

$$B = \frac{\mu_0 n / a^2}{2(r^2+a^2)^{3/2}} \quad \text{.... (i)}$$

where, $I =$ current through the coil, $a =$ radius of a circular loop, $r =$ distance of point from the centre along the axis and $n =$ number of turns in the coil.

Area of the coil, $A = \pi a^2$

$$\Rightarrow \quad a^2 = \frac{A}{\pi} \quad \text{.... (ii)}$$

and it $r \gg a$ then, $\left(r^2 + a^2\right)^{3/2} \approx r^3$ ... (iii)

From Eqs. (i), (ii) and (iii), we get

$$\Rightarrow \quad B = \left(\frac{\mu_0 n I}{2r^3}\right) \frac{A}{\pi} \times \frac{2}{2}$$

$$B = \frac{2\mu_0 n / A}{4\pi r^3}$$

So, option (b) is correct.
