Date 03/06/21

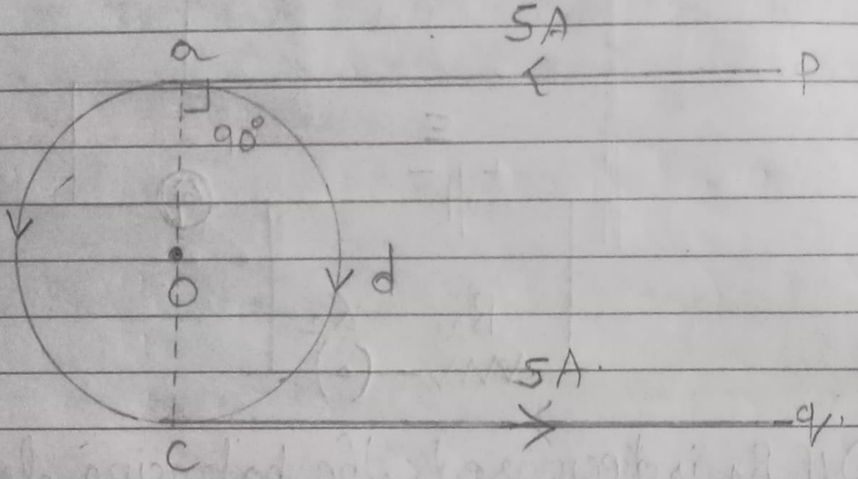
Chapter-4

Moving Charges & Magnetism.

Home Assignment - 1

Q.1. In figure abcd is a circular coil of the non-insulated thin uniform conductor. Conductors pa and qc are very long straight parallel conductors tangential to the coil at the points a and c. If a current of 5A enters the coil from p to a, Find the magnetic induction at O, the centre of the coil. The diameter of the coil is 10cm.

Ans.



Given,
abcd is a circular coil of the non-insulated thin uniform conductor,
Now,
Current = 5A.
Let the small ~~one~~ element of th coil be dl.
diameter of coil = 10cm.
radius of coil = $\frac{10}{2}$ = 5 cm = 0.05m.

~~Now,~~
~~Magnetic field at point O due pa.~~
$\cancel{\vec{B}_1 = \frac{\mu_0 I}{2a}}$

$$\Rightarrow B_1 = \frac{10^{-7} \times 4 \times 3.14 \times 5}{2 \times 5 \times 10^{-2}}$$

$$= 6.28 \times 10^{-5}$$

~~Now,~~

~~Magnetic field at point O due pa.~~

$$dB_1 = \frac{\mu_0}{4\pi} \cdot \frac{I\,dl.\sin\theta}{r^2}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{I\,dl\,\sin 90^\circ}{r^2}$$

$$= \frac{\mu_0}{4\pi} \cdot I$$

Now,

Here, by making the circular coil as two semicircles,

The contribution of current to both semicircles due to pa will be same.

Here,

The direction of magnetic field due to the semicircle abc will be out of the plane of the paper.

&, the direction of magnetic field due to the semicircle adc will be into the plane of the paper.

Hence,

the direction of magnetic field will be opposite on the point O due to both the semicircle. & As the contribution of current is equal they have equal magnitude of the magnetic field at point O.

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Hence,
We can conclude that.
Magnetic field at point O due to the whole circular coill will be
$dB = 0$.
Now,
Magnetic field at point O due to pa will be:

$$B_{pa} = \frac{\mu_0}{4\pi}\frac{I}{r}(\sin\theta_1 + \sin\theta_2)$$

$$= 10^{-7} \times \frac{5}{5\times10^{-2}} (\sin 0° + \sin 90°)$$

$$= 10^{-5} T.$$

Magnetic field at point O due to qc. will be

$$B_{qc} = \frac{\mu_0}{4\pi}\frac{I}{r}(\sin\theta_1 + \sin\theta_2)$$

$$= 10^{-7} \times \frac{5}{5\times10^{-2}} (\sin 0° + \sin 90°)$$

$$= 10^{-5} T$$

Now,
Magnetic field at point O will be

$$B_{net} = B_{pa} + B_{qc}$$

$$= (10^{-5} + 10^{-5}) T.$$

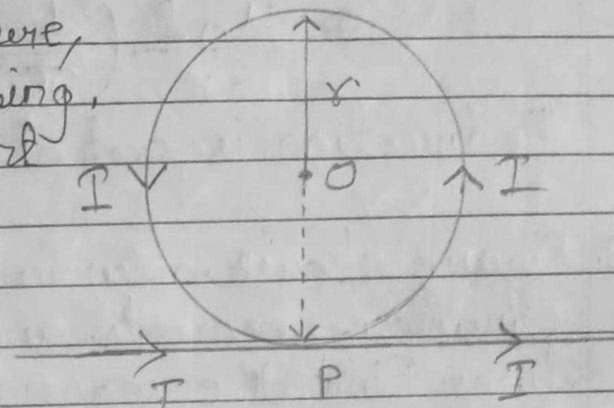
$$= 2\times10^{-5} T.$$

The direction of magnetic field at point O will be out of the plane of the paper.

Q.2. A ~~lag~~ long wire is ~~baunt~~ bent as shown in the figure. What will be the ~~magnetic~~ magnitude and direction of the field at

The centre O of the circular portion, if a current I is passed through the wire? Assume that the various portions of the wire do not touch at point P.

Ans- In the along side figure, The current is flowing through a long bent wire.



Given,
Current = I.
Here,
The radius of the circular wire = r
Now,
The magnetic field due to the long straight wire at point O will be.

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{I}{r} (\sin\theta_1 + \sin\theta_2)$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{I}{r} (\sin 90^\circ + \sin 90^\circ)$$

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

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

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

Now,
The magnetic field at point O due to the long circular wire will be

$$B_2 = \frac{\mu_0 I}{2r}$$

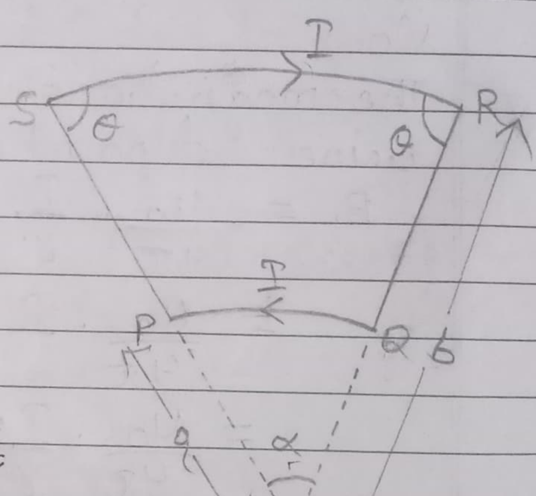
Now,
The net magnetic field at point O.

$$B_{net} = B_1 + B_2$$
$$= \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{2r}$$
$$= \frac{\mu_0 I}{2r}\left(\frac{1}{\pi} + 1\right)$$

The direction is out of the plane of the paper

Q.3. Figure shows a current loop having two circular segments and joined by two radial lines. Find the magnetic field at the centre O.

Ans- In the alongside figure,



Given;
Current = I
$\angle POQ = \alpha$.
As we know that.
In an arc.

$\theta = \frac{l}{r}$ So, $\alpha = \frac{l}{r}$

Now,
The Magnetic field at point O due to the arc RS

$$dB_{RS} = \frac{\mu_0}{4\pi} \cdot \frac{I\,dl \cdot \sin\theta}{r^2}$$
$$\Rightarrow B_{RS} = \int dB_{RS} = \int \frac{\mu_0}{4\pi} \frac{I\,dl \cdot \sin\theta}{b^2}$$
$$= \frac{\mu_0}{4\pi} \cdot \frac{I \cdot \alpha b \cdot}{b^2}$$

sin 90°

$$= \frac{\mu_0}{4\pi} \cdot \frac{I\alpha \cancel{b}}{\cancel{b^2}} \cdot 1$$

$$= \frac{\mu_0 I \alpha}{4\pi b}$$ (into the plane of the paper)

Now, ~~$= \frac{\mu_0}{}$~~

The magnetic field at point O due to the arc PQ will be:

$$dB_{PQ} = \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2}$$

$$\Rightarrow B_{PQ} = \int dB_{PQ} = \int \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{I \alpha a}{a^2} \cdot \sin 90^\circ$$

$$= \frac{\mu_0}{4\pi} \frac{I \alpha a}{a^2} \cdot 1$$

$$= \frac{\mu_0 I \alpha}{4\pi a}$$ (out of the plane)

~~Now,~~
~~The net magnetic field at point O will be~~
~~$B_{net} = B_{PQ} + B_{RS}$~~
~~$B_{net} = B_{RS} + B_{PQ}$~~

Now,
The net magnetic field at point O will be

$$B_{net} = B_{PQ} - B_{RS}$$

$$= \frac{\mu_0 I \alpha}{4\pi a} - \frac{\mu_0 I \alpha}{4\pi b}$$

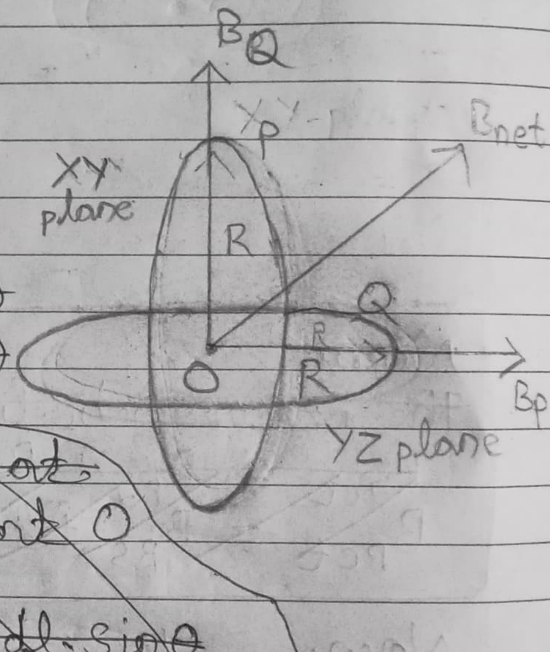
$$= \frac{\mu_0 I \alpha b - \mu_0 I \alpha a}{4\pi ab}$$

$$= \frac{\mu_0 I \alpha (b - a)}{4\pi ab}$$

The direction of the magnetic field B_{net} is coming out of the plane.

Q4. Two identical circular loop coils, P and Q each of radius R, carrying current 1 A and $\sqrt{3}$ A respectively, are placed concentrically and perpendicular to each other lying in the XY and YZ planes. Find the magnitude and direction of the net magnetic field at the centre of the coils.

Ans- In the alongside figure,



Given,
Radius of Circles P & Q are R.
Current in Circle P = 1 A
Current in Circle Q = $\sqrt{3}$ A
~~Now~~
~~Magnetic field at point~~
Magnetic field at point O due to circle P

$$B_p = \int dB_p = \int \frac{\mu_0}{4\pi} \frac{I\, dl \sin\theta}{r^2}$$
$$= \frac{\mu_0}{4\pi} \frac{I \cdot 2\pi R \cdot \sin}{R^2}$$

Now,
Magnetic field at point O due to circle P

$$B_p = \frac{\mu_0 I_P}{2R}.$$

The direction is towards its axis.

Magnetic field at point O due to circle Q

$$B_Q = \frac{\mu_0 I_Q}{2R}.$$

Now

The net Magnetic field at point O will be

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

$$= \sqrt{\left(\frac{\mu_0 I_P}{2R}\right)^2 + \left(\frac{\mu_0 I_Q}{2R}\right)^2}$$

$$= \sqrt{\frac{\mu_0^2 I_P^2}{4R^2} + \frac{\mu_0^2 I_Q^2}{4R^2}}$$

$$= \frac{\mu_0}{2R}\sqrt{I_P^2 + I_Q^2}$$

$$= \frac{\mu_0}{2R}\sqrt{1+3}$$

$$= \frac{\mu_0}{2R} \times 2. = \frac{\mu_0}{R}$$

The direction of the magnetic field at point O will be

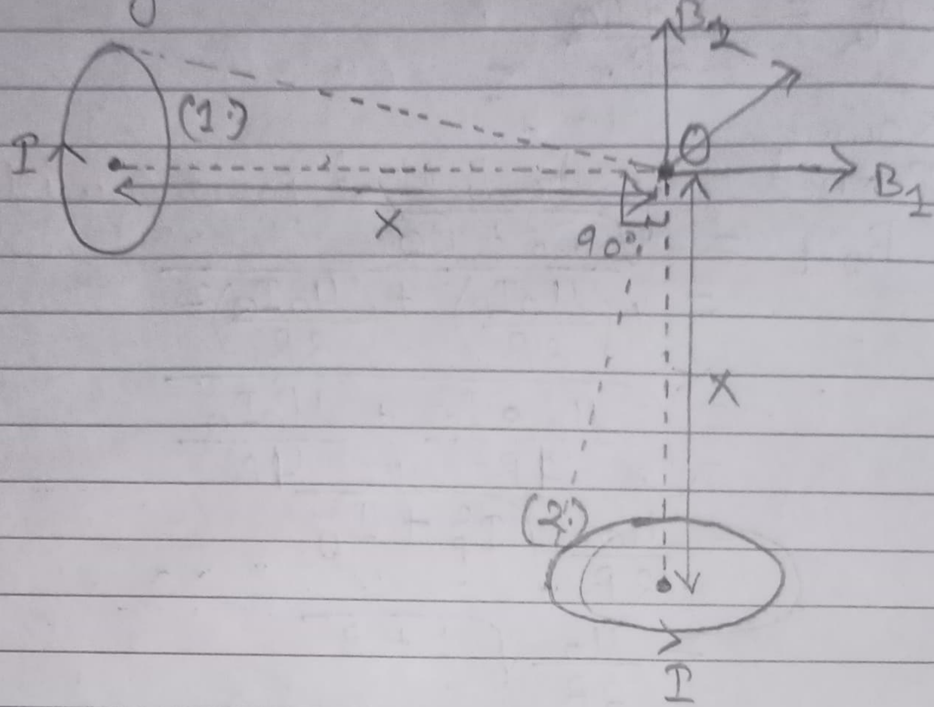
$$\tan\theta = \frac{B_P}{B_Q} = \frac{\mu_0 I_P}{2R} \times \frac{2R}{\mu_0 I_Q}$$

$$= \frac{I_P}{I_Q} = \frac{1}{\sqrt{3}}$$

$$\Rightarrow \theta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = 30^\circ \text{ with x-direction}$$

Q.5. Two very small identical circular loop (1) and (2.) carrying equal current I are placed vertically (with respect of the plane of the paper with their geometrical axes perpendicular to each other as shown in the figure. Find the magnitude and direction of the net magnetic field produced at the point O.

Ans-



In the above figure,
Given,
Current in both circle = I
distance of point O from loops = x.
Now,
Magnetic field at point O due to loop (1.)

$$\cancel{B_1 = \int dB_1 = \int \frac{\mu_0}{4\pi} \cdot \frac{I \cdot dl \cdot \sin\theta}{2(x+R)^{3/2}}}$$

$$\cancel{= \frac{\mu_0}{4\pi} \cdot I \cdot 2\pi R}$$

$$B_1 = \frac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}}$$

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

Magnetic field at point O due to loop (2.)

$$B_2 = \frac{\mu_0 I \cdot a^2}{2(x^2+a^2)^{3/2}}$$

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

Now,

$$B_{net} = \sqrt{\frac{\mu_0^2 I^2 R^4}{2(x^2+R^2)^{3/2}} + \frac{\mu_0^2 I^2 R^4}{2(x^2+R^2)^{3/2}}}$$

$$= \sqrt{\frac{2\,\mu_0^2 I R^4}{2^2(x^2+R^2)^{3/2}}}$$

$$= \sqrt{2\,\mu_0 I R^2}$$

Now,

$$B_{net} = \sqrt{B_1^2 + B_2^2}$$

$$= \sqrt{2}\,B_1 \qquad B_1 = B_2$$

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

The Magnetic Field is. $\frac{\mu_0}{\sqrt{2}} \cdot \frac{I R^2}{(x^2+R^2)^{3/2}}$

The direction of Magnetic Field will be

$$\tan\theta = \frac{B_1}{B_2} = \frac{I_1}{I_2} = 1$$

$\Rightarrow \theta = \tan^{-1}(1) = 45^\circ$ with loop 1 axis.