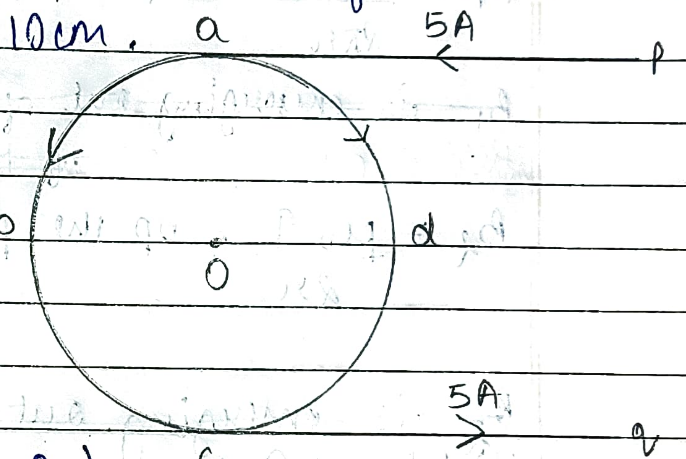
Home Assignment :

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 center of the coil. The diameter of the coil is 10cm.



1A- Field due to Ring at O = 0

Field due to semi-infinite coil pa :

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

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

$$= 10^{-5} \times 1 = 1 \times 10^{-5}\ T$$

Field due to semi-infinite coil qc :

$$B_{qc} = \frac{\mu_0 I}{4\pi r}(\sin\theta_1 + \sin\theta_2) = \frac{10^{-7} \times 5 \times (\sin 0^\circ + \sin 90^\circ)}{5 \times 10^{-2}} = 1 \times 10^{-5}\ T$$

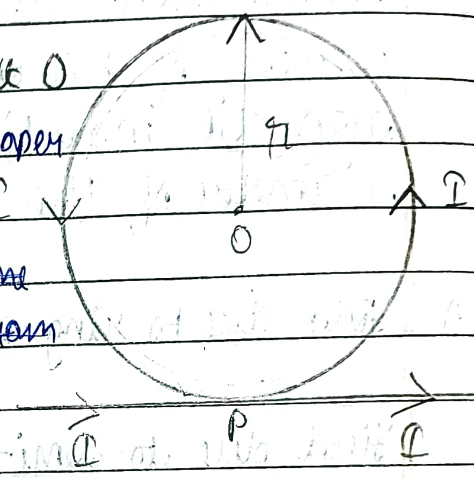
$$B = B_{pa} + B_{qc} = 10^{-5} + 10^{-5} = 2 \times 10^{-5}\ T$$

2 A long wire is bent as shown in the figure. What will be the magnitude and direction of the field at the center O of the circular position, if a current I is passed through the wire? Assume that the various portions of the wire do not touch at point P.

A → Field due to straight conductor at O

$B_1 = \frac{\mu_0 I}{2\pi r}$, up the plane of paper

~~B_1 is emerging out of the plane of the diagram~~



→ Field due to circular loop at O

$B_2 = \frac{\mu_0 I}{2r}$, up the plane of paper

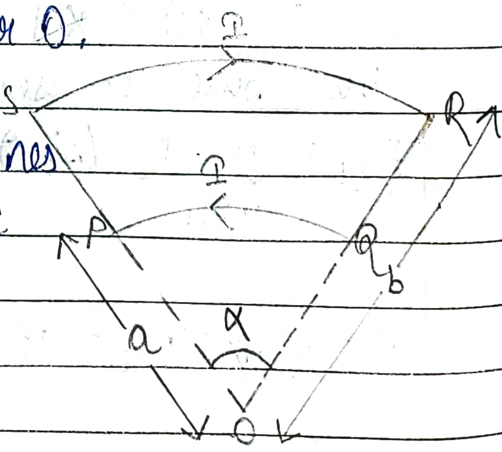
~~B_2 is emerging out of the plane of the diagram~~

Total Field at O :

$B_{net} = B_1 + B_2 = \frac{\mu_0 I}{2r}\left(1 + \frac{1}{\pi}\right)$, up the plane of paper.

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

A - Since the point O lies on lines SP and QR, so the magnetic field at O due to these straight portions is zero.



The magnetic field at O due to the circular segment PQ is

$$B_1 = \frac{\mu_0 I}{4\pi a^2} l$$

Here, l = length of arc PQ $= \alpha a$

$$\therefore B_1 = \frac{\mu_0 I \alpha}{4\pi a}$$, directed normally upward

Similarly, the magnetic field at O due to the circular segment SR is

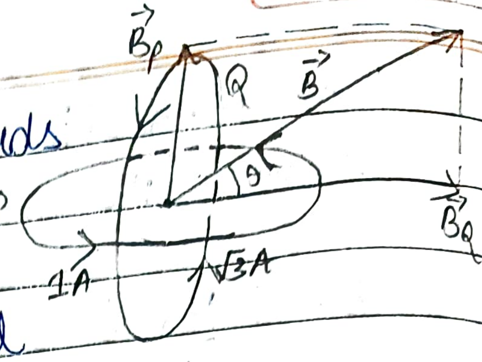
$$B_2 = \frac{\mu_0 I \alpha}{4\pi b}$$, directed normally downward.

The resultant field at O is

$$B = B_1 - B_2 = \frac{\mu_0 I \alpha}{4\pi}\left[\frac{1}{a} - \frac{1}{b}\right]$$

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

4 Two identical circular coils, P and Q each of radius R, carrying currents 1A 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.



A- $\vec{B}_P = \frac{\mu_0 1}{2R}$, vertically upwards

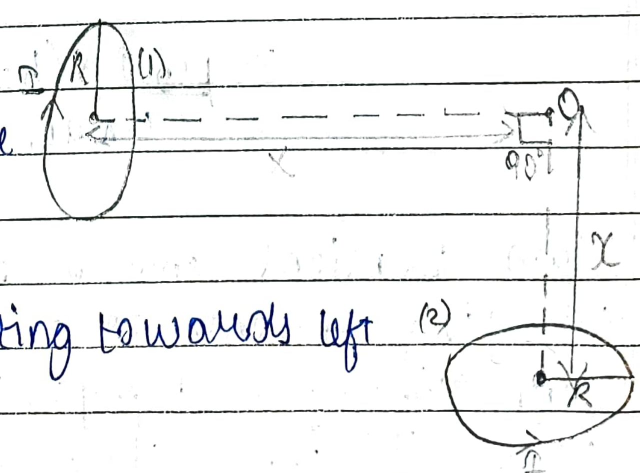
$\vec{B}_Q = \frac{\mu_0 \sqrt{3}}{2R}$, along horizontal

$$B = \sqrt{B_P^2 + B_Q^2} = \left[\left(\frac{\mu_0 1}{2R}\right)^2 + \left(\frac{\mu_0 \sqrt{3}}{2R}\right)^2\right]^{1/2}$$

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

$$\tan\theta = \frac{B_P}{B_Q} = \frac{1}{\sqrt{3}} \Rightarrow \theta = 30^\circ$$

5 Two very small identical circular loop (1) and (2) carrying equal current I are placed vertically (with respect to 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.



A- Magnetic field at O due to loop 1,

$$B_1 = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}$$, acting towards left

Magnetic field at O due to ~~p~~ loop 2,

$$B_2 = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}$$, acting ~~towards~~ vertically upwards

Here, R is radius of each loop.

$$B = \sqrt{B_1^2 + B_2^2}$$

$$= \sqrt{2}B_1 \quad (\because B_1 = B_2)$$

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