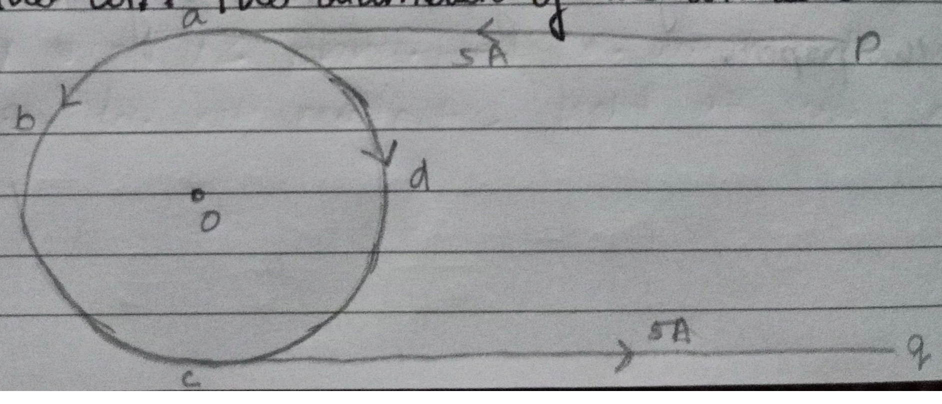
Home Assignment

02/07/21

(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 tangetial to the coil at 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 10 cm.



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Ans. Magnetic field at point O due to the straight conductor PA is

$$B_1 = \frac{1}{2}\left[\frac{\mu_0 I}{2\pi r}\right]$$

$$= \frac{4\pi \times 10^{-7} \times 5}{4\pi \times 5 \times 10^{-2}} = 10^{-5} T.$$

Similarly, magnetic field at a point O due to straight conductor QC is

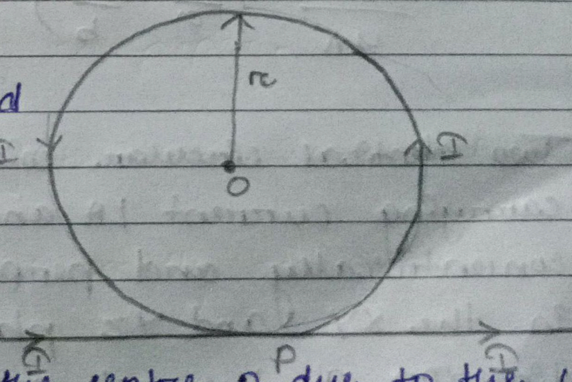
$$B_2 = \frac{\mu_0 I}{4\pi r} = 10^{-5} T$$

Both the magnetic fields B_1 and B_2 are acting normally out of the plane of the paper. So the total magnetic field $\vec{B}$ is

$$B = B_1 + B_2$$

$$= 10^{-5} + 10^{-5} = 2 \times 10^{-5} T.$$

(2) A long wire is bent as shown in the figure. What will be the magnitude and direction of the field at the 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.

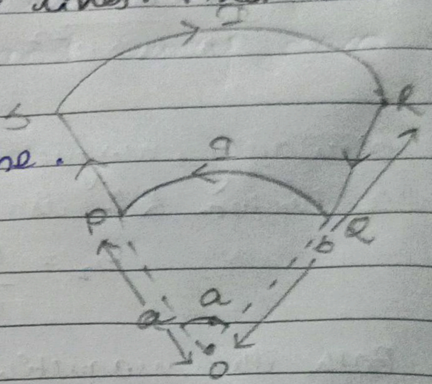


Ans. Magnitude of the magnetic field at O due to the straight part of the wire is $B_1 = \frac{\mu_0}{2\pi} \cdot \frac{I}{R}$, normally out of the plane of paper. Magnetic field at the centre O due to the current loop of radius R is $B_2 = \frac{\mu_0 I}{2R}$ normally into the plane of paper.

Resultant field at O is

$$B = B_2 - B_1 = \frac{\mu_0 I}{2R}\left(1 - \frac{1}{\pi}\right)$$, normally into 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 centre O.



Ans. Magnetic field due to side lines will be zero as they exist on same line.

Due to circular arc:

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

Here for $r = a$

$$\vec{B_1} = \frac{\mu_0 I \theta}{4\pi a} \quad \text{(Outside)}$$

For $r = b$

$$\vec{B_2} = \frac{\mu_0 I \theta}{4\pi b} \quad \text{(Inside)}$$

Net magnetic field

$$B = B_1 - B_2$$

$$= \frac{\mu_0 I \theta}{4\pi}\left(\frac{1}{a} - \frac{1}{b}\right)$$

(4) Two identical circular 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. We know that, $B = \frac{\mu_0 I}{2R}$

$$B_1 = \frac{\mu_0}{2R} \cdot 1$$

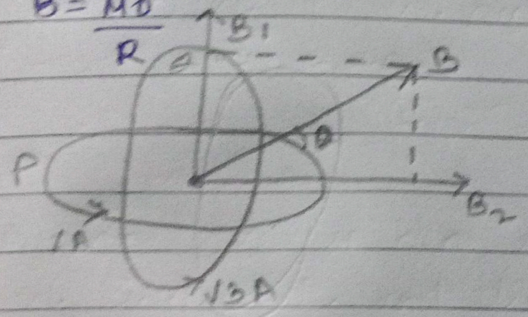
$$B_2 = \frac{\mu_0}{2R} \cdot \sqrt{3}$$

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

$$= \sqrt{\left(\frac{\mu_0}{2R}\right)^2 + \left(\frac{\mu_0}{2R} \cdot \sqrt{3}\right)^2}$$

$$B = \frac{\mu_0}{2R} \sqrt{1+3} = \frac{\mu_0}{2R} \cdot \sqrt{4}$$

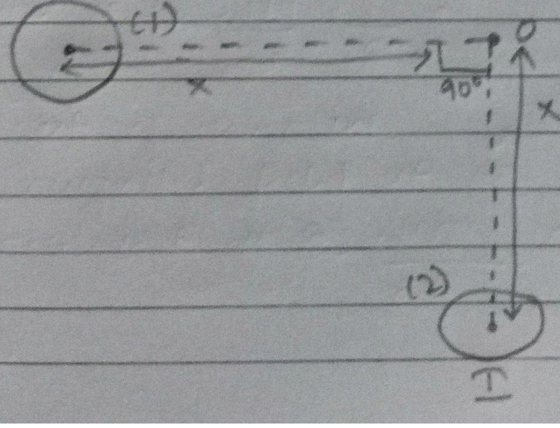
$$B = \frac{\mu_0}{R}$$



$\tan\theta = \frac{B_1}{B_2} = \frac{1}{\sqrt{3}}$

$\Rightarrow \theta = 30°$.

(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 the 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. Magnetic field at point O, due to circular loop (1)

$$B_1 = \frac{\mu_0 I a^2}{2(a^2+x^2)^{3/2}}$$, along the axis and towards the loop (1)

where a is the radius of the circular loop.

Magnetic field at point O, due to circular loop (2)

$$B_2 = \frac{\mu_0 I a^2}{2(a^2+x^2)^{3/2}}$$ along the axis and away from loop(1)

Net magnetic field at point O.