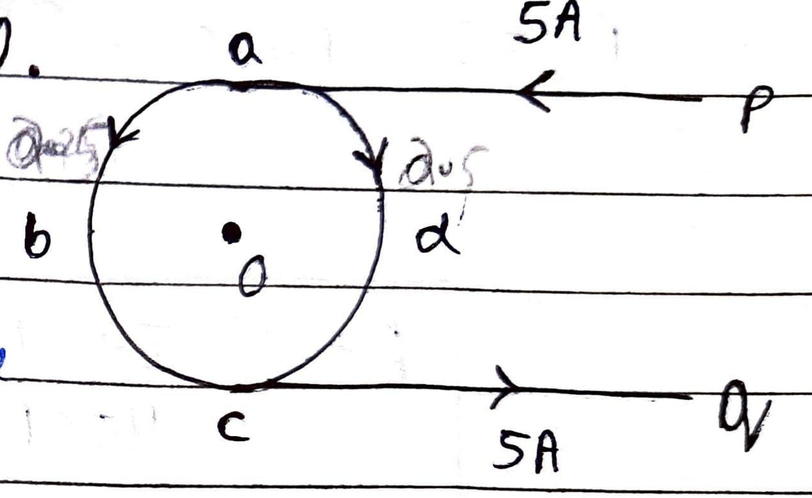
Home Assignment

(1) Find the magnetic induction at O.

$r = 0.05m$

Current



The Magnetic field induction at O due to current through circular coil abcd will be zero. Because magnetic field induction at O due to current through segment abc of the coil is equal and opposite to that adc.

B induction due to current through long straight conductor

$$B_1 = \frac{\mu_0}{4\pi}\frac{I}{r}(\sin 90^\circ + \sin 0^\circ) = \frac{1}{2}\frac{\mu_0 I}{2\pi r} = 10^{-7} \times \frac{5}{5\times10^{-2}}$$

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

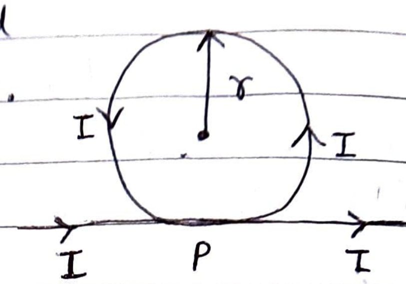
Outward normally on the plane of paper through CA,

$B_2 = \frac{\mu_0}{4\pi}\frac{I}{r}(\sin 90^\circ + \sin 0^\circ) = 10^{-7} \times \frac{5}{5 \times 10^{-2}} = 10^{-5}\ T$

Total magnetic field induction at O

$B = B_1 + B_2 = 10^{-5} + 10^{-5} = \boxed{2 \times 10^{-5}}$ Normally outward to the plane of paper.

(2) What will be the magnitude and direction of the field at the center O.



Field due to straight conductor

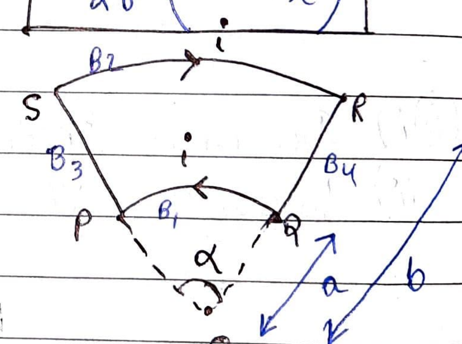
$B_1 = \frac{\mu_0 I}{2\pi r}$, up the plane of the paper

Field due to circular loop at point O

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

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

(3) Find $\vec{B}$ at the center O.



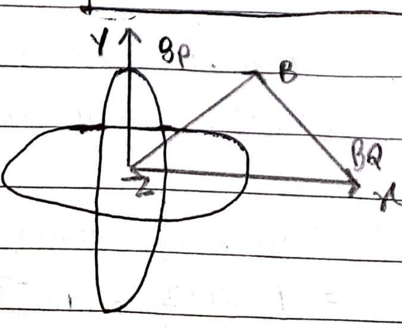
$B_1 = \frac{\mu_0}{4\pi}\frac{i\alpha}{a}$ (outward) $\quad B_2 = \frac{\mu_0}{4\pi}\frac{i\alpha}{b}$ (inward)

$B_3 = 0 \quad B_4 = 0$ } O is along straight wire

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

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

(4)



$B_P = \frac{\mu_0 I}{2\pi R} = \frac{\mu_0}{2\pi R}$

$B_Q = \frac{\mu_0 I}{2\pi R} = \frac{\mu_0\sqrt{3}}{2\pi R}$

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

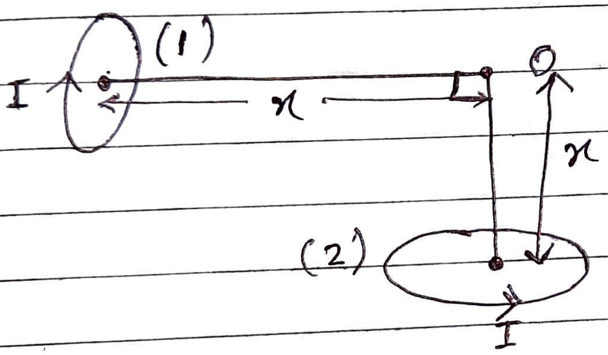
$$= \frac{\mu_0}{2\pi R}\sqrt{4} = \boxed{\frac{\mu_0}{4R}}$$

$$\tan\beta = \frac{AB}{B} = \frac{\frac{\mu_0}{2\pi R}}{\frac{\mu_0\sqrt{3}}{2\pi R}} = \frac{1}{\sqrt{3}}$$

$$\boxed{\beta = 30^\circ} \text{ Ans}$$

The direction of net magnetic field is 30° with the x-direc.

(5)



Find mag and dir of net $\vec{B}$ at O.

B due to circular loop

$$= \frac{\mu_0}{4\pi}\frac{2\pi R^2 P}{(x^2 + R)^{3/2}}$$

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

$$|\vec{B}_{net}| = \sqrt{2}\,|\vec{B}| = \frac{\sqrt{2}\,\mu_0 R^2 I}{2(x^2 + R^2)^{3/2}}$$

direction is along $\frac{-\hat{i} - \hat{j}}{\sqrt{2}}$