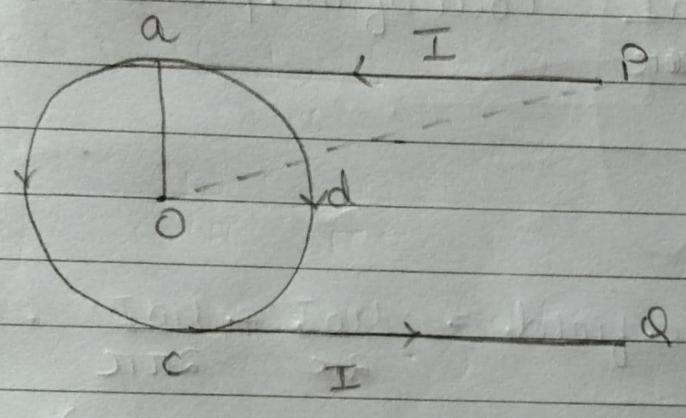
17/21 Home Assignment:

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 & c. if a current of 5 A enters the coil from P to a field the magnetic induction at centre O. The diameter of the coil is 10cm

Ans-



Magnetic induction at centre O due to both segments abc, adc is equal and opposite i.e, $\frac{\mu_0 I}{4\pi}$ so the magnetic induction is zero.

Now, magnetic field at O due to pa will be

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

$I = 5A$

$a = 5cm = 5\times10^{-2}\,m$

$$\Rightarrow \frac{10^{-7}\times4\pi}{4\pi} \times \frac{5}{5\times10^{-2}} (\sin 0° + \sin 90°)$$

$$\Rightarrow 1\times10^{-5}\,T$$

$$B_{qc} = B_{pa} = 1\times10^{-5}\,T$$

$\therefore B_{net} = 2\times10^{-5}\,T$ at the centre O.

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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? Assure that the various portion of the wire donot touch at point P.

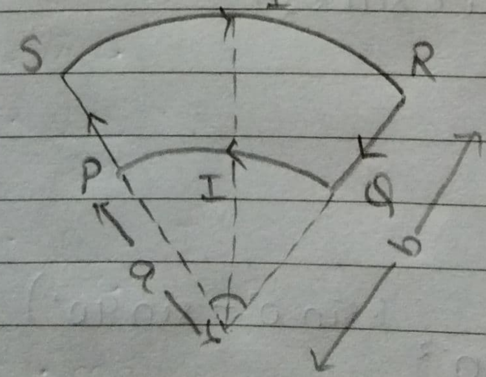
Ans- $B_{\text{due to coil}} = \frac{\mu_0 I}{2r}$ (out of the plane).

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

Total magnetic field $= \frac{\mu_0 I}{2r} + \frac{\mu_0 I}{2\pi r}$

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

3) Figure shows a current loop having two circular segments and joined by 2 radial lines. Find the magnetic field at centre O.



Magnetic field due to SP and RQ at point O is zero as angle betn dl & r is 0° and 180°

Magnetic field due to PQ,

$$dB = \frac{\mu_0}{4\pi} \times \frac{I\,dl}{r^2} \sin\theta \qquad [\theta = 90^\circ]$$

$$B = \int dB$$
$$= \int \frac{\mu_0}{4\pi} \times \frac{I\,dl}{r^2} \times \sin\theta$$
$$= \frac{\mu_0}{4\pi} \frac{I}{r^2} \int dl$$
$$= \frac{\mu_0}{4\pi} \frac{I}{r^2} r\theta \qquad [l = r\theta]$$
$$= \frac{\mu_0 I \theta}{4\pi r}$$

Now, $\theta = \alpha$
$r = a$

$$B_{\text{due to PQ at O}} = \frac{\mu_0 I \alpha}{4\pi a} \odot$$

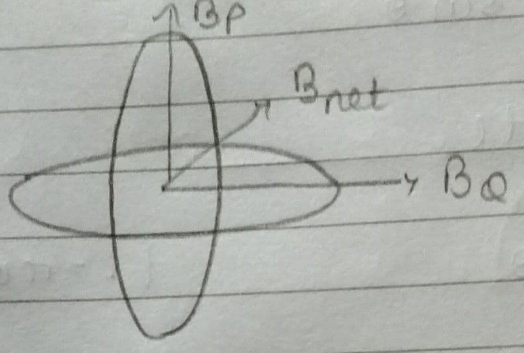
Magnetic field due to SR, $\frac{\mu_0 I \theta}{4 r \pi}$

Now $r = b$, $\theta = \alpha$

$$B_{\text{due to SR}} = \frac{\mu_0 I \alpha}{4\pi b}$$

$$B_{net} = B_1 - B_2$$
$$= \frac{\mu_0 I \alpha}{4\pi a} - \frac{\mu_0 I \alpha}{4\pi b}$$
$$= \frac{\mu_0 I \alpha}{4\pi} \left(\frac{b-a}{ab} \right) \odot$$

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



Magnetic field at the centre of closed loop $= \frac{\mu_0 I}{2r}$

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

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

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

$$= \frac{\mu_0}{2r}\sqrt{1^2 + (\sqrt{3})^2}$$

$$= \frac{\mu_0}{2r} \times 2$$

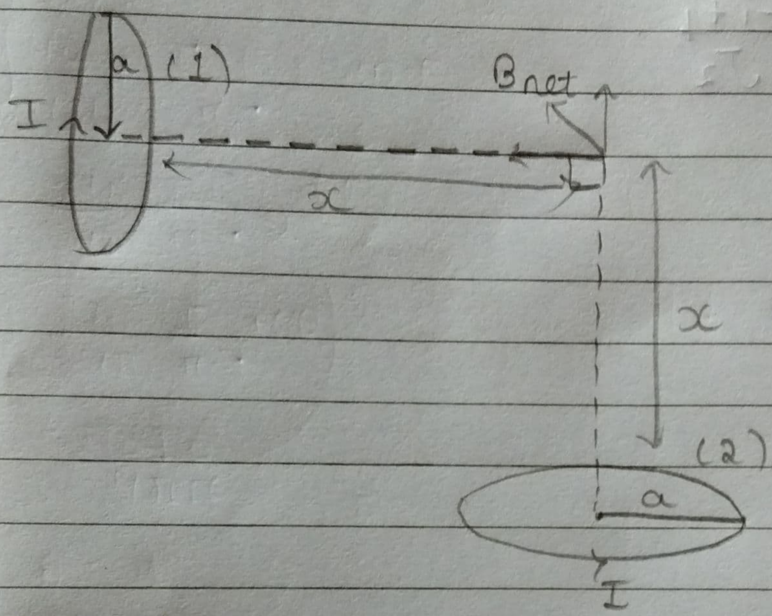
$$= \frac{\mu_0}{r} \text{ T}$$

Resultant magnetic field makes an angle θ.

$$\tan\theta = \frac{B_P}{B_Q} = \frac{I_P}{I_Q} = \frac{1}{\sqrt{3}}$$

$$\theta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = 30°$$

5) Two very small identical circular loop (1) & (2) carrying equal current I are placed vertically with the geometrical areas ⊥ to each other. Find the magnitude and direction of the magnetic field produced at O.



$$B = \frac{\mu_0 I \, dl \, a}{4\pi (a^2+x^2)^{3/2}}$$

$$B_{net} = \sqrt{(B_1)^2 + (B_2)^2 + 2B_1B_2\cos\theta}$$
$$= \sqrt{B_1^2 + B_2^2}$$

As $|B_1| = |B_2|$

$$B_{net} = \sqrt{2}|B|$$
$$= \sqrt{2} \times \frac{\mu_0 I \, dl \, a}{4\pi (a^2+x^2)^{3/2}}$$ $dl = 2\pi a$
$$= \sqrt{2} \frac{\mu_0}{2} \frac{I a^2}{(a^2+x^2)^{3/2}}$$
$$= \frac{\mu_0 I a^2}{\sqrt{2} (a^2+x^2)^{3/2}}$$

$\hat{B}_1 = -\hat{i}$, $\vec{B}_1 = -1\hat{i}$

$\hat{B}_2 = \hat{j}$ $\vec{B}_2 = 1\hat{j}$

$$\vec{B}_{net} = -\hat{i} + \hat{j}$$

$$\frac{\vec{B}}{|\vec{B}_{net}|} = \frac{-\hat{i} + \hat{j}}{\sqrt{2}}$$