

CHAPTER – 35 MAGNETIC FIELD DUE TO CURRENT

$$1. \quad F = q\vec{v} \times \vec{B} \text{ or, } B = \frac{F}{qv} = \frac{F}{ITv} = \frac{N}{A \cdot \text{sec.} / \text{sec.}} = \frac{N}{A \cdot m}$$

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{or, } \mu_0 = \frac{2\pi r B}{I} = \frac{m \times N}{A \cdot m \times A} = \frac{N}{A^2}$$

$$2. \quad i = 10 \text{ A, } d = 1 \text{ m}$$

$$B = \frac{\mu_0 i}{2\pi r} = \frac{10^{-7} \times 4\pi \times 10}{2\pi \times 1} = 20 \times 10^{-6} \text{ T} = 2 \mu\text{T}$$

Along +ve Y direction.

$$3. \quad d = 1.6 \text{ mm}$$

$$\text{So, } r = 0.8 \text{ mm} = 0.0008 \text{ m}$$

$$i = 20 \text{ A}$$

$$\vec{B} = \frac{\mu_0 i}{2\pi r} = \frac{4\pi \times 10^{-7} \times 20}{2 \times \pi \times 8 \times 10^{-4}} = 5 \times 10^{-3} \text{ T} = 5 \text{ mT}$$

$$4. \quad i = 100 \text{ A, } d = 8 \text{ m}$$

$$B = \frac{\mu_0 i}{2\pi r} = \frac{4\pi \times 10^{-7} \times 100}{2 \times \pi \times 8} = 2.5 \mu\text{T}$$

$$5. \quad \mu_0 = 4\pi \times 10^{-7} \text{ T-m/A}$$

$$r = 2 \text{ cm} = 0.02 \text{ m, } I = 1 \text{ A, } \vec{B} = 1 \times 10^{-5} \text{ T}$$

We know: Magnetic field due to a long straight wire carrying current = $\frac{\mu_0 I}{2\pi r}$

$$\vec{B} \text{ at P} = \frac{4\pi \times 10^{-7} \times 1}{2\pi \times 0.02} = 1 \times 10^{-5} \text{ T upward}$$

$$\text{net B} = 2 \times 1 \times 10^{-5} \text{ T} = 20 \mu\text{T}$$

$$B \text{ at Q} = 1 \times 10^{-5} \text{ T downwards}$$

$$\text{Hence net } \vec{B} = 0$$

6. (a) The maximum magnetic field is $B + \frac{\mu_0 I}{2\pi r}$ which are along the left keeping the sense along the direction of traveling current.

$$(b) \text{The minimum } B - \frac{\mu_0 I}{2\pi r}$$

$$\text{If } r = \frac{\mu_0 I}{2\pi B} \quad B \text{ net} = 0$$

$$r < \frac{\mu_0 I}{2\pi B} \quad B \text{ net} = 0$$

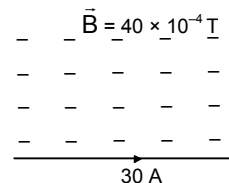
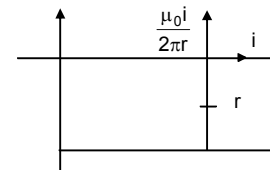
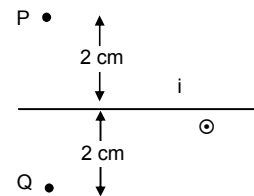
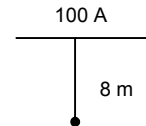
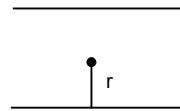
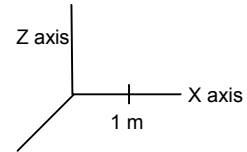
$$r > \frac{\mu_0 I}{2\pi B} \quad B \text{ net} = B - \frac{\mu_0 I}{2\pi r}$$

$$7. \quad \mu_0 = 4\pi \times 10^{-7} \text{ T-m/A, } I = 30 \text{ A, } B = 4.0 \times 10^{-4} \text{ T Parallel to current.}$$

$$\vec{B} \text{ due to wire at a pt. 2 cm}$$

$$= \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 30}{2\pi \times 0.02} = 3 \times 10^{-4} \text{ T}$$

$$\text{net field} = \sqrt{(3 \times 10^{-4})^2 + (4 \times 10^{-4})^2} = 5 \times 10^{-4} \text{ T}$$



8. $i = 10 \text{ A}$. (\hat{K})

$B = 2 \times 10^{-3} \text{ T}$ South to North (\hat{J})

To cancel the magnetic field the point should be chosen so that the net magnetic field is along $-\hat{J}$ direction.

\therefore The point is along $-\hat{i}$ direction or along west of the wire.

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

$$\Rightarrow 2 \times 10^{-3} = \frac{4\pi \times 10^{-7} \times 10}{2\pi \times r}$$

$$\Rightarrow r = \frac{2 \times 10^{-7}}{2 \times 10^{-3}} = 10^{-3} \text{ m} = 1 \text{ mm}.$$

9. Let the two wires be positioned at O & P

$$R = OA = \sqrt{(0.02)^2 + (0.02)^2} = \sqrt{8 \times 10^{-4}} = 2.828 \times 10^{-2} \text{ m}$$

(a) \vec{B} due to Q, at $A_1 = \frac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.02} = 1 \times 10^{-4} \text{ T}$ (\perp towards up the line)

\vec{B} due to P, at $A_1 = \frac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.06} = 0.33 \times 10^{-4} \text{ T}$ (\perp towards down the line)

net $\vec{B} = 1 \times 10^{-4} - 0.33 \times 10^{-4} = 0.67 \times 10^{-4} \text{ T}$

(b) \vec{B} due to O at $A_2 = \frac{2 \times 10^{-7} \times 10}{0.01} = 2 \times 10^{-4} \text{ T}$ \perp down the line

\vec{B} due to P at $A_2 = \frac{2 \times 10^{-7} \times 10}{0.03} = 0.67 \times 10^{-4} \text{ T}$ \perp down the line

net \vec{B} at $A_2 = 2 \times 10^{-4} + 0.67 \times 10^{-4} = 2.67 \times 10^{-4} \text{ T}$

(c) \vec{B} at A_3 due to O = $1 \times 10^{-4} \text{ T}$ \perp towards down the line

\vec{B} at A_3 due to P = $1 \times 10^{-4} \text{ T}$ \perp towards down the line

Net \vec{B} at $A_3 = 2 \times 10^{-4} \text{ T}$

(d) \vec{B} at A_4 due to O = $\frac{2 \times 10^{-7} \times 10}{2.828 \times 10^{-2}} = 0.7 \times 10^{-4} \text{ T}$ towards SE

\vec{B} at A_4 due to P = $0.7 \times 10^{-4} \text{ T}$ towards SW

Net $\vec{B} = \sqrt{(0.7 \times 10^{-4})^2 + (0.7 \times 10^{-4})^2} = 0.989 \times 10^{-4} \approx 1 \times 10^{-4} \text{ T}$

10. $\cos \theta = \frac{1}{2}$, $\theta = 60^\circ$ & $\angle AOB = 60^\circ$

$$B = \frac{\mu_0 I}{2\pi r} = \frac{10^{-7} \times 2 \times 10}{2 \times 10^{-2}} = 10^{-4} \text{ T}$$

So net is $[(10^{-4})^2 + (10^{-4})^2 + 2(10^{-8}) \cos 60^\circ]^{1/2}$
 $= 10^{-4} [1 + 1 + 2 \times \frac{1}{2}]^{1/2} = 10^{-4} \times \sqrt{3} \text{ T} = 1.732 \times 10^{-4} \text{ T}$

11. (a) \vec{B} for X = \vec{B} for Y

Both are oppositely directed hence net $\vec{B} = 0$

(b) \vec{B} due to X = \vec{B} due to Y both directed along Z-axis

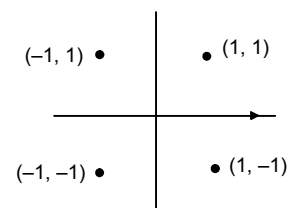
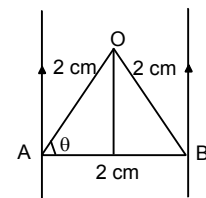
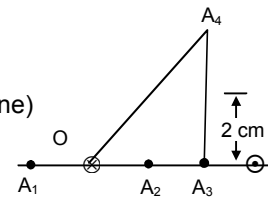
$$\text{Net } \vec{B} = \frac{2 \times 10^{-7} \times 2 \times 5}{1} = 2 \times 10^{-6} \text{ T} = 2 \mu\text{T}$$

(c) \vec{B} due to X = \vec{B} due to Y both directed opposite to each other.

Hence Net $\vec{B} = 0$

(d) \vec{B} due to X = \vec{B} due to Y = $1 \times 10^{-6} \text{ T}$ both directed along $(-)$ ve Z-axis

Hence Net $\vec{B} = 2 \times 1.0 \times 10^{-6} = 2 \mu\text{T}$



12. (a) For each of the wire

Magnitude of magnetic field

$$= \frac{\mu_0 i}{4\pi r} (\sin 45^\circ + \sin 45^\circ) = \frac{\mu_0 \times 5}{4\pi \times (5/2)} \frac{2}{\sqrt{2}}$$

For AB \odot for BC \odot For CD \otimes and for DA \otimes .

The two \odot and 2 \otimes fields cancel each other. Thus $B_{\text{net}} = 0$

- (b) At point Q_1

$$\text{due to (1) } B = \frac{\mu_0 i}{2\pi \times 2.5 \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 5 \times 10^{-2}} = 4 \times 10^{-5} \odot$$

$$\text{due to (2) } B = \frac{\mu_0 i}{2\pi \times (15/2) \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 15 \times 10^{-2}} = (4/3) \times 10^{-5} \odot$$

$$\text{due to (3) } B = \frac{\mu_0 i}{2\pi \times (5 + 5/2) \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 15 \times 10^{-2}} = (4/3) \times 10^{-5} \odot$$

$$\text{due to (4) } B = \frac{\mu_0 i}{2\pi \times 2.5 \times 10^{-2}} = \frac{4\pi \times 5 \times 2 \times 10^{-7}}{2\pi \times 5 \times 10^{-2}} = 4 \times 10^{-5} \odot$$

$$B_{\text{net}} = [4 + 4 + (4/3) + (4/3)] \times 10^{-5} = \frac{32}{3} \times 10^{-5} = 10.6 \times 10^{-5} \approx 1.1 \times 10^{-4} \text{ T}$$

At point Q_2

$$\text{due to (1) } \frac{\mu_0 i}{2\pi \times (2.5) \times 10^{-2}} \odot$$

$$\text{due to (2) } \frac{\mu_0 i}{2\pi \times (15/2) \times 10^{-2}} \odot$$

$$\text{due to (3) } \frac{\mu_0 i}{2\pi \times (2.5) \times 10^{-2}} \otimes$$

$$\text{due to (4) } \frac{\mu_0 i}{2\pi \times (15/2) \times 10^{-2}} \otimes$$

$$B_{\text{net}} = 0$$

At point Q_3

$$\text{due to (1) } \frac{4\pi \times 10^{-7} \times 5}{2\pi \times (15/2) \times 10^{-2}} = 4/3 \times 10^{-5} \otimes$$

$$\text{due to (2) } \frac{4\pi \times 10^{-7} \times 5}{2\pi \times (5/2) \times 10^{-2}} = 4 \times 10^{-5} \otimes$$

$$\text{due to (3) } \frac{4\pi \times 10^{-7} \times 5}{2\pi \times (5/2) \times 10^{-2}} = 4 \times 10^{-5} \otimes$$

$$\text{due to (4) } \frac{4\pi \times 10^{-7} \times 5}{2\pi \times (15/2) \times 10^{-2}} = 4/3 \times 10^{-5} \otimes$$

$$B_{\text{net}} = [4 + 4 + (4/3) + (4/3)] \times 10^{-5} = \frac{32}{3} \times 10^{-5} = 10.6 \times 10^{-5} \approx 1.1 \times 10^{-4} \text{ T}$$

For Q_4

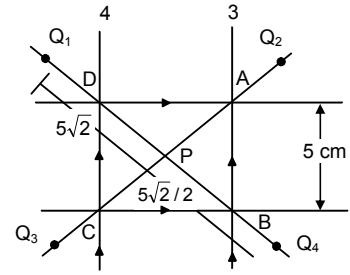
$$\text{due to (1) } 4/3 \times 10^{-5} \otimes$$

$$\text{due to (2) } 4 \times 10^{-5} \otimes$$

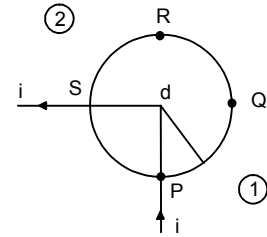
$$\text{due to (3) } 4/3 \times 10^{-5} \otimes$$

$$\text{due to (4) } 4 \times 10^{-5} \otimes$$

$$B_{\text{net}} = 0$$



13. Since all the points lie along a circle with radius = 'd'
Hence 'R' & 'Q' both at a distance 'd' from the wire.
So, magnetic field \vec{B} due to are same in magnitude.
As the wires can be treated as semi infinite straight current carrying conductors. Hence magnetic field $\vec{B} = \frac{\mu_0 i}{4\pi d}$



At P

B_1 due to 1 is 0

B_2 due to 2 is $\frac{\mu_0 i}{4\pi d}$

At Q

B_1 due to 1 is $\frac{\mu_0 i}{4\pi d}$

B_2 due to 2 is 0

At R

B_1 due to 1 is 0

B_2 due to 2 is $\frac{\mu_0 i}{4\pi d}$

At S

B_1 due to 1 is $\frac{\mu_0 i}{4\pi d}$

B_2 due to 2 is 0

$$14. B = \frac{\mu_0 i}{4\pi d} 2 \sin \theta$$

$$= \frac{\mu_0 i}{4\pi d} \frac{2 \times x}{2 \times \sqrt{d^2 + \frac{x^2}{4}}} = \frac{\mu_0 i x}{4\pi d \sqrt{d^2 + \frac{x^2}{4}}}$$

(a) When $d \gg x$

Neglecting x w.r.t. d

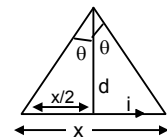
$$B = \frac{\mu_0 i x}{\mu_0 d \sqrt{d^2}} = \frac{\mu_0 i x}{\mu_0 d^2}$$

$$\therefore B \propto \frac{1}{d^2}$$

(b) When $x \gg d$, neglecting d w.r.t. x

$$B = \frac{\mu_0 i x}{4\pi d x / 2} = \frac{2\mu_0 i}{4\pi d}$$

$$\therefore B \propto \frac{1}{d}$$

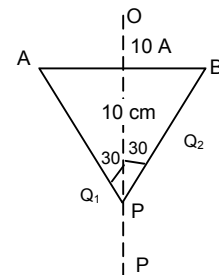


15. $I = 10 \text{ A}$, $a = 10 \text{ cm} = 0.1 \text{ m}$

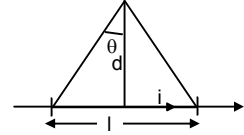
$$r = OP = \frac{\sqrt{3}}{2} \times 0.1 \text{ m}$$

$$B = \frac{\mu_0 I}{4\pi r} (\sin \phi_1 + \sin \phi_2)$$

$$= \frac{10^{-7} \times 10 \times 1}{\frac{\sqrt{3}}{2} \times 0.1} = \frac{2 \times 10^{-5}}{1.732} = 1.154 \times 10^{-5} \text{ T} = 11.54 \mu\text{T}$$



$$16. B_1 = \frac{\mu_0 i}{2\pi d}, \quad B_2 = \frac{\mu_0 i}{4\pi d} (2 \times \sin\theta) = \frac{\mu_0 i}{4\pi d} \frac{2 \times \ell}{2\sqrt{d^2 + \frac{\ell^2}{4}}} = \frac{\mu_0 i \ell}{4\pi d \sqrt{d^2 + \frac{\ell^2}{4}}}$$



$$B_1 - B_2 = \frac{1}{100} B_2 \Rightarrow \frac{\mu_0 i}{2\pi d} - \frac{\mu_0 i \ell}{4\pi d \sqrt{d^2 + \frac{\ell^2}{4}}} = \frac{\mu_0 i}{200\pi d}$$

$$\Rightarrow \frac{\mu_0 i \ell}{4\pi d \sqrt{d^2 + \frac{\ell^2}{4}}} = \frac{\mu_0 i}{\pi d} \left(\frac{1}{2} - \frac{1}{200} \right)$$

$$\Rightarrow \frac{\ell}{4\sqrt{d^2 + \frac{\ell^2}{4}}} = \frac{99}{200} \quad \Rightarrow \frac{\ell^2}{d^2 + \frac{\ell^2}{4}} = \left(\frac{99 \times 4}{200} \right)^2 = \frac{156816}{40000} = 3.92$$

$$\Rightarrow \ell^2 = 3.92 d^2 + \frac{3.92}{4} \ell^2$$

$$\left(\frac{1 - 3.92}{4} \right) \ell^2 = 3.92 d^2 \Rightarrow 0.02 \ell^2 = 3.92 d^2 \Rightarrow \frac{d^2}{\ell^2} = \frac{0.02}{3.92} = \frac{d}{\ell} = \sqrt{\frac{0.02}{3.92}} = 0.07$$

17. As resistances vary as r & $2r$

Hence Current along ABC = $\frac{i}{3}$ & along ADC = $\frac{2i}{3}$

Now,

$$\vec{B} \text{ due to ADC} = 2 \left[\frac{\mu_0 i \times 2 \times 2 \times \sqrt{2}}{4\pi 3a} \right] = \frac{2\sqrt{2}\mu_0 i}{3\pi a}$$

$$\vec{B} \text{ due to ABC} = 2 \left[\frac{\mu_0 i \times 2 \times \sqrt{2}}{4\pi 3a} \right] = \frac{2\sqrt{2}\mu_0 i}{6\pi a}$$

$$\text{Now } \vec{B} = \frac{2\sqrt{2}\mu_0 i}{3\pi a} - \frac{2\sqrt{2}\mu_0 i}{6\pi a} = \frac{\sqrt{2}\mu_0 i}{3\pi a} \quad \otimes$$

$$18. A_0 = \sqrt{\frac{a^2}{16} + \frac{a^2}{4}} = \sqrt{\frac{5a^2}{16}} = \frac{a\sqrt{5}}{4}$$

$$D_0 = \sqrt{\left(\frac{3a}{4} \right)^2 + \left(\frac{a}{2} \right)^2} = \sqrt{\frac{9a^2}{16} + \frac{a^2}{4}} = \sqrt{\frac{13a^2}{16}} = \frac{a\sqrt{13}}{4}$$

Magnetic field due to AB

$$B_{AB} = \frac{\mu_0}{4\pi} \times \frac{i}{2(a/4)} (\sin(90 - \alpha) + \sin(90 - \alpha))$$

$$= \frac{\mu_0 \times 2i}{4\pi a} 2\cos\alpha = \frac{\mu_0 \times 2i}{4\pi a} \times 2 \times \frac{(a/2)}{a(\sqrt{5}/4)} = \frac{2\mu_0 i}{\pi\sqrt{5}}$$

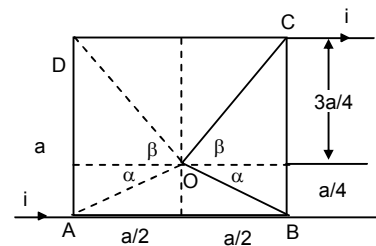
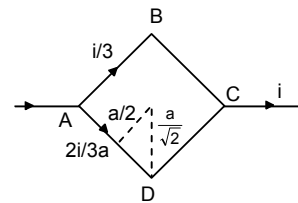
Magnetic field due to DC

$$B_{DC} = \frac{\mu_0}{4\pi} \times \frac{i}{2(3a/4)} 2\sin(90^\circ - \alpha)$$

$$= \frac{\mu_0 i \times 4 \times 2}{4\pi \times 3a} \cos\beta = \frac{\mu_0 i}{\pi \times 3a} \times \frac{(a/2)}{(\sqrt{13}a/4)} = \frac{2\mu_0 i}{\pi a 3\sqrt{13}}$$

The magnetic field due to AD & BC are equal and appropriate hence cancel each other.

$$\text{Hence, net magnetic field is } \frac{2\mu_0 i}{\pi\sqrt{5}} - \frac{2\mu_0 i}{\pi a 3\sqrt{13}} = \frac{2\mu_0 i}{\pi a} \left[\frac{1}{\sqrt{5}} - \frac{1}{3\sqrt{13}} \right]$$



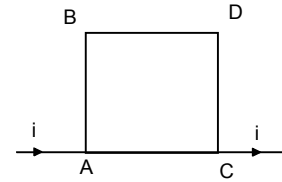
19. \vec{B} due to BC &

\vec{B} due to AD at Pt 'P' are equal ore Opposite

Hence net $\vec{B} = 0$

Similarly, due to AB & CD at P = 0

\therefore The net \vec{B} at the Centre of the square loop = zero.



20. For AB B is along \odot $B = \frac{\mu_0 i}{4\pi r} (\sin 60^\circ + \sin 60^\circ)$

For AC $B \quad \otimes \quad B = \frac{\mu_0 i}{4\pi r} (\sin 60^\circ + \sin 60^\circ)$

For BD $B \quad \odot \quad B = \frac{\mu_0 i}{4\pi r} (\sin 60^\circ)$

For DC $B \quad \otimes \quad B = \frac{\mu_0 i}{4\pi r} (\sin 60^\circ)$

\therefore Net $B = 0$

21. (a) $\triangle ABC$ is Equilateral

$AB = BC = CA = \ell/3$

Current = i

$$AO = \frac{\sqrt{3}}{2} a = \frac{\sqrt{3} \times \ell}{2 \times 3} = \frac{\ell}{2\sqrt{3}}$$

$$\phi_1 = \phi_2 = 60^\circ$$

$$\text{So, } MO = \frac{\ell}{6\sqrt{3}} \quad \text{as } AM : MO = 2 : 1$$

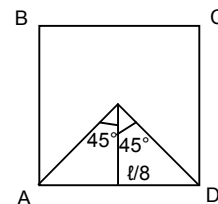
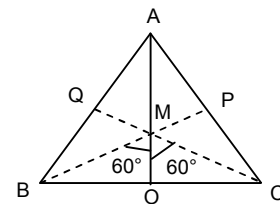
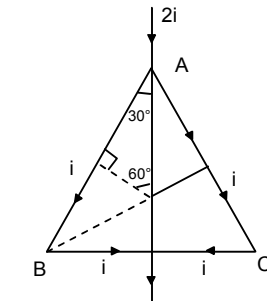
\vec{B} due to BC at \odot .

$$= \frac{\mu_0 i}{4\pi r} (\sin \phi_1 + \sin \phi_2) = \frac{\mu_0 i}{4\pi} \times i \times 6\sqrt{3} \times \sqrt{3} = \frac{\mu_0 i \times 9}{2\pi \ell}$$

$$\text{net } \vec{B} = \frac{9\mu_0 i}{2\pi \ell} \times 3 = \frac{27\mu_0 i}{2\pi \ell}$$

$$(b) \vec{B} \text{ due to AD} = \frac{\mu_0 i \times 8}{4\pi \times \ell} \sqrt{2} = \frac{8\sqrt{2}\mu_0 i}{4\pi \ell}$$

$$\text{Net } \vec{B} = \frac{8\sqrt{2}\mu_0 i}{4\pi \ell} \times 4 = \frac{8\sqrt{2}\mu_0 i}{\pi \ell}$$



22. $\sin(\alpha/2) = \frac{r}{x}$

$$\Rightarrow r = x \sin(\alpha/2)$$

Magnetic field B due to AR

$$\frac{\mu_0 i}{4\pi r} [\sin(180 - (90 - (\alpha/2))) + 1]$$

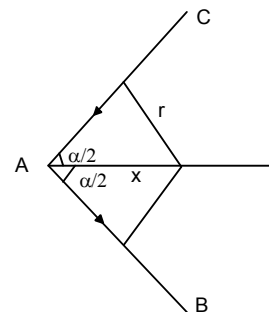
$$\Rightarrow \frac{\mu_0 i [\sin(90 - (\alpha/2)) + 1]}{4\pi \times \sin(\alpha/2)}$$

$$= \frac{\mu_0 i (\cos(\alpha/2) + 1)}{4\pi \times \sin(\alpha/2)}$$

$$= \frac{\mu_0 i 2\cos^4(\alpha/4)}{4\pi \times 2\sin(\alpha/4)\cos(\alpha/4)} = \frac{\mu_0 i}{4\pi x} \cot(\alpha/4)$$

The magnetic field due to both the wire.

$$\frac{2\mu_0 i}{4\pi x} \cot(\alpha/4) = \frac{\mu_0 i}{2\pi x} \cot(\alpha/4)$$



23. \vec{B}_{AB}

$$\frac{\mu_0 i \times 2}{4\pi b} \times 2\sin\theta = \frac{\mu_0 i \sin\theta}{\pi b}$$

$$= \frac{\mu_0 i \ell}{\pi b \sqrt{\ell^2 + b^2}} = \vec{B}_{DC}$$

$$\therefore \sin(\ell^2 + b^2) = \frac{(\ell/2)}{\sqrt{\ell^2/4 + b^2/4}} = \frac{\ell}{\sqrt{\ell^2 + b^2}}$$

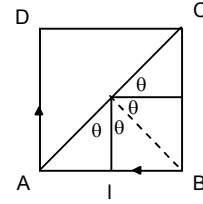
\vec{B}_{BC}

$$\frac{\mu_0 i \times 2}{4\pi \ell} \times 2 \times 2\sin\theta' = \frac{\mu_0 i \sin\theta'}{\pi \ell}$$

$$\therefore \sin\theta' = \frac{(b/2)}{\sqrt{\ell^2/4 + b^2/4}} = \frac{b}{\sqrt{\ell^2 + b^2}}$$

$$= \frac{\mu_0 i b}{\pi \ell \sqrt{\ell^2 + b^2}} = \vec{B}_{AD}$$

$$\text{Net } \vec{B} = \frac{2\mu_0 i \ell}{\pi b \sqrt{\ell^2 + b^2}} + \frac{2\mu_0 i b}{\pi \ell \sqrt{\ell^2 + b^2}} = \frac{2\mu_0 i (\ell^2 + b^2)}{\pi \ell b \sqrt{\ell^2 + b^2}} = \frac{2\mu_0 i \sqrt{\ell^2 + b^2}}{\pi \ell b}$$



24. $2\theta = \frac{2\pi}{n} \Rightarrow \theta = \frac{\pi}{n}, \quad \ell = \frac{2\pi r}{n}$

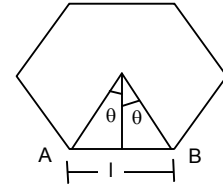
$$\tan\theta = \frac{\ell}{2x} \Rightarrow x = \frac{\ell}{2\tan\theta}$$

$$\frac{\ell}{2} = \frac{\pi r}{n}$$

$$B_{AB} = \frac{\mu_0 i}{4\pi(x)} (\sin\theta + \sin\theta) = \frac{\mu_0 i 2\tan\theta \times 2\sin\theta}{4\pi \ell}$$

$$= \frac{\mu_0 i 2\tan(\pi/n) 2\sin(\pi/n)n}{4\pi 2\pi r} = \frac{\mu_0 i n \tan(\pi/n) \sin(\pi/n)}{2\pi^2 r}$$

$$\text{For } n \text{ sides, } B_{\text{net}} = \frac{\mu_0 i n \tan(\pi/n) \sin(\pi/n)}{2\pi^2 r}$$



25. Net current in circuit = 0

Hence the magnetic field at point P = 0

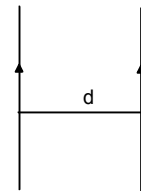
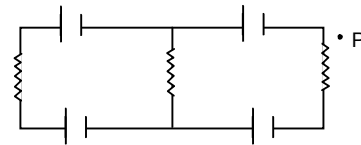
[Owing to wheat stone bridge principle]

26. Force acting on 10 cm of wire is 2×10^{-5} N

$$\frac{dF}{dl} = \frac{\mu_0 i_1 i_2}{2\pi d}$$

$$\Rightarrow \frac{2 \times 10^{-5}}{10 \times 10^{-2}} = \frac{\mu_0 \times 20 \times 20}{2\pi d}$$

$$\Rightarrow d = \frac{4\pi \times 10^{-7} \times 20 \times 20 \times 10 \times 10^{-2}}{2\pi \times 2 \times 10^{-5}} = 400 \times 10^{-3} = 0.4 \text{ m} = 40 \text{ cm}$$



27. $i = 10 \text{ A}$

Magnetic force due to two parallel Current Carrying wires.

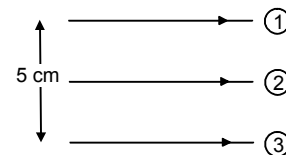
$$F = \frac{\mu_0 I_1 I_2}{2\pi r}$$

So, \vec{F} or 1 = \vec{F} by 2 + \vec{F} by 3

$$= \frac{\mu_0 \times 10 \times 10}{2\pi \times 5 \times 10^{-2}} + \frac{\mu_0 \times 10 \times 10}{2\pi \times 10 \times 10^{-2}}$$

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

$$= \frac{2 \times 10^{-3}}{5} + \frac{10^{-3}}{5} = \frac{3 \times 10^{-3}}{5} = 6 \times 10^{-4} \text{ N towards middle wire}$$

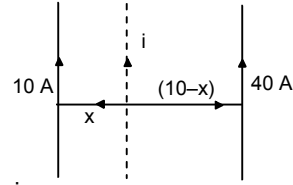


$$28. \frac{\mu_0 10i}{2\pi x} = \frac{\mu_0 i 40}{2\pi(10-x)}$$

$$\Rightarrow \frac{10}{x} = \frac{40}{10-x} \Rightarrow \frac{1}{x} = \frac{4}{10-x}$$

$$\Rightarrow 10-x = 4x \Rightarrow 5x = 10 \Rightarrow x = 2 \text{ cm}$$

The third wire should be placed 2 cm from the 10 A wire and 8 cm from 40 A wire.



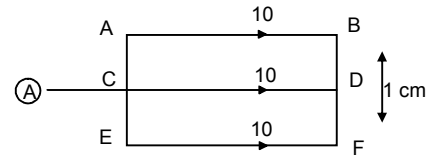
$$29. F_{AB} = F_{CD} + F_{EF}$$

$$= \frac{\mu_0 \times 10 \times 10}{2\pi \times 1 \times 10^{-2}} + \frac{\mu_0 \times 10 \times 10}{2\pi \times 2 \times 10^{-2}}$$

$$= 2 \times 10^{-3} + 10^{-3} = 3 \times 10^{-3} \quad \text{downward.}$$

$$F_{CD} = F_{AB} + F_{EF}$$

As F_{AB} & F_{EF} are equal and oppositely directed hence $F = 0$



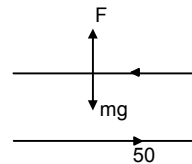
$$30. \frac{\mu_0 i_1 i_2}{2\pi d} = mg \quad (\text{For a portion of wire of length 1m})$$

$$\Rightarrow \frac{\mu_0 \times 50 \times i_2}{2\pi \times 5 \times 10^{-3}} = 1 \times 10^{-4} \times 9.8$$

$$\Rightarrow \frac{4\pi \times 10^{-7} \times 50 \times i_2}{2\pi \times 5 \times 10^{-3}} = 9.8 \times 10^{-4}$$

$$\Rightarrow 2 \times i_2 \times 10^{-3} = 9.3 \times 10^{-3} \times 10^{-1}$$

$$\Rightarrow i_2 = \frac{9.8}{2} \times 10^{-1} = 0.49 \text{ A}$$



$$31. I_2 = 6 \text{ A}$$

$$I_1 = 10 \text{ A}$$

$$F_{PQ}$$

$$'F' \text{ on } dx = \frac{\mu_0 i_1 i_2}{2\pi x} dx = \frac{\mu_0 i_1 i_2}{2\pi} \frac{dx}{x} = \frac{\mu_0 \times 30}{\pi} \frac{dx}{x}$$

$$\vec{F}_{PQ} = \frac{\mu_0 \times 30}{x} \int_1^3 \frac{dx}{x} = 30 \times 4 \times 10^{-7} \times [\log x]_1^2$$

$$= 120 \times 10^{-7} [\log 3 - \log 1]$$

$$\text{Similarly force of } \vec{F}_{RS} = 120 \times 10^{-7} [\log 3 - \log 1]$$

$$\text{So, } \vec{F}_{PQ} = \vec{F}_{RS}$$

$$\vec{F}_{PS} = \frac{\mu_0 \times i_1 i_2}{2\pi \times 1 \times 10^{-2}} - \frac{\mu_0 \times i_1 i_2}{2\pi \times 2 \times 10^{-2}}$$

$$= \frac{2 \times 6 \times 10 \times 10^{-7}}{10^{-2}} - \frac{2 \times 10^{-7} \times 6 \times 6}{2 \times 10^{-2}} = 8.4 \times 10^{-4} \text{ N (Towards right)}$$

$$\vec{F}_{RQ} = \frac{\mu_0 \times i_1 i_2}{2\pi \times 3 \times 10^{-2}} - \frac{\mu_0 \times i_1 i_2}{2\pi \times 2 \times 10^{-2}}$$

$$= \frac{4\pi \times 10^{-7} \times 6 \times 10}{2\pi \times 3 \times 10^{-2}} - \frac{4\pi \times 10^{-7} \times 6 \times 6}{2\pi \times 2 \times 10^{-2}} = 4 \times 10^{-4} + 36 \times 10^{-5} = 7.6 \times 10^{-4} \text{ N}$$

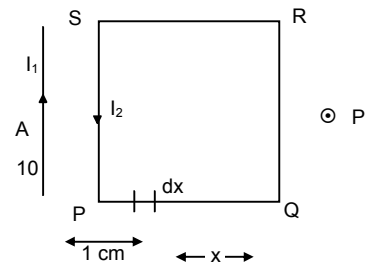
Net force towards down

$$= (8.4 + 7.6) \times 10^{-4} = 16 \times 10^{-4} \text{ N}$$

$$32. B = 0.2 \text{ mT}, \quad i = 5 \text{ A}, \quad n = 1, \quad r = ?$$

$$B = \frac{n\mu_0 i}{2r}$$

$$\Rightarrow r = \frac{n \times \mu_0 i}{2B} = \frac{1 \times 4\pi \times 10^{-7} \times 5}{2 \times 0.2 \times 10^{-3}} = 3.14 \times 5 \times 10^{-3} \text{ m} = 15.7 \times 10^{-3} \text{ m} = 15.7 \times 10^{-1} \text{ cm} = 1.57 \text{ cm}$$



33. $B = \frac{n\mu_0 i}{2r}$
 $n = 100, \quad r = 5 \text{ cm} = 0.05 \text{ m}$
 $\vec{B} = 6 \times 10^{-5} \text{ T}$
 $i = \frac{2rB}{n\mu_0} = \frac{2 \times 0.05 \times 6 \times 10^{-5}}{100 \times 4\pi \times 10^{-7}} = \frac{3}{6.28} \times 10^{-1} = 0.0477 \approx 48 \text{ mA}$

34. 3×10^5 revolutions in 1 sec.

1 revolutions in $\frac{1}{3 \times 10^5} \text{ sec}$

$i = \frac{q}{t} = \frac{1.6 \times 10^{-19}}{\left(\frac{1}{3 \times 10^5}\right)} \text{ A}$

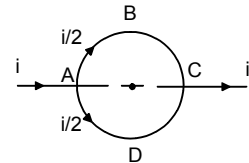
$B = \frac{\mu_0 i}{2r} = \frac{4\pi \times 10^{-7} \cdot 1.6 \times 10^{-19} \cdot 3 \times 10^5}{2 \times 0.5 \times 10^{-10}} \cdot \frac{2\pi \times 1.6 \times 3}{0.5} \times 10^{-11} = 6.028 \times 10^{-10} \approx 6 \times 10^{-10} \text{ T}$

35. $I = i/2$ in each semicircle

$ABC = \vec{B} = \frac{1}{2} \times \frac{\mu_0 (i/2)}{2a}$ downwards

$ADC = \vec{B} = \frac{1}{2} \times \frac{\mu_0 (i/2)}{2a}$ upwards

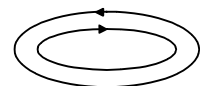
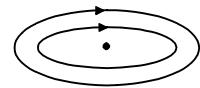
Net $\vec{B} = 0$



36. $r_1 = 5 \text{ cm}$ $r_2 = 10 \text{ cm}$
 $n_1 = 50$ $n_2 = 100$
 $i = 2 \text{ A}$

(a) $B = \frac{n_1 \mu_0 i}{2r_1} + \frac{n_2 \mu_0 i}{2r_2}$
 $= \frac{50 \times 4\pi \times 10^{-7} \times 2}{2 \times 5 \times 10^{-2}} + \frac{100 \times 4\pi \times 10^{-7} \times 2}{2 \times 10 \times 10^{-2}}$
 $= 4\pi \times 10^{-4} + 4\pi \times 10^{-4} = 8\pi \times 10^{-4}$

(b) $B = \frac{n_1 \mu_0 i}{2r_1} - \frac{n_2 \mu_0 i}{2r_2} = 0$



37. Outer Circle

$n = 100, \quad r = 100 \text{ m} = 0.1 \text{ m}$
 $i = 2 \text{ A}$

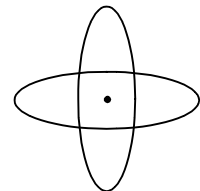
$\vec{B} = \frac{n\mu_0 i}{2a} = \frac{100 \times 4\pi \times 10^{-7} \times 2}{2 \times 0.1} = 4\pi \times 10^{-4}$ horizontally towards West.

Inner Circle

$r = 5 \text{ cm} = 0.05 \text{ m}, \quad n = 50, \quad i = 2 \text{ A}$

$\vec{B} = \frac{n\mu_0 i}{2r} = \frac{4\pi \times 10^{-7} \times 2 \times 50}{2 \times 0.05} = 4\pi \times 10^{-4}$ downwards

Net $B = \sqrt{(4\pi \times 10^{-4})^2 + (4\pi \times 10^{-4})^2} = \sqrt{32\pi^2 \times 10^{-8}} = 17.7 \times 10^{-4} \approx 18 \times 10^{-4} = 1.8 \times 10^{-3} = 1.8 \text{ mT}$



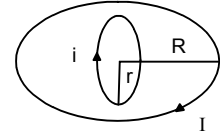
38. $r = 20 \text{ cm}, \quad i = 10 \text{ A}, \quad V = 2 \times 10^6 \text{ m/s}, \quad \theta = 30^\circ$

$F = e(\vec{V} \times \vec{B}) = eVB \sin \theta$

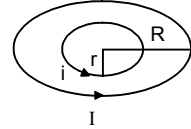
$= 1.6 \times 10^{-19} \times 2 \times 10^6 \times \frac{\mu_0 i}{2r} \sin 30^\circ$

$= \frac{1.6 \times 10^{-19} \times 2 \times 10^6 \times 4\pi \times 10^{-7} \times 10}{2 \times 2 \times 20 \times 10^{-2}} = 16\pi \times 10^{-19} \text{ N}$

39. \vec{B} Large loop = $\frac{\mu_0 I}{2R}$
 'i' due to larger loop on the smaller loop
 $= i(A \times B) = i AB \sin 90^\circ = i \times \pi r^2 \times \frac{\mu_0 I}{2r}$



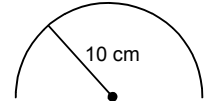
40. The force acting on the smaller loop
 $F = i l B \sin \theta$
 $= \frac{i 2\pi r \mu_0 I i}{2R \times 2} = \frac{\mu_0 i I \pi r}{2R}$



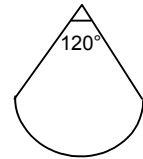
41. $i = 5$ Ampere, $r = 10 \text{ cm} = 0.1 \text{ m}$
 As the semicircular wire forms half of a circular wire,

$$\text{So, } \vec{B} = \frac{1}{2} \frac{\mu_0 i}{2r} = \frac{1}{2} \times \frac{4\pi \times 10^{-7} \times 5}{2 \times 0.1}$$

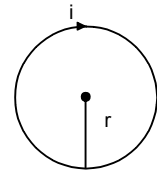
$$= 15.7 \times 10^{-6} \text{ T} \approx 16 \times 10^{-6} \text{ T} = 1.6 \times 10^{-5} \text{ T}$$



42. $B = \frac{\mu_0 i}{2R} \frac{\theta}{2\pi} = \frac{2\pi}{3 \times 2\pi} \times \frac{\mu_0 i}{2R}$
 $= \frac{4\pi \times 10^{-7} \times 6}{6 \times 10^{-2}} = 4\pi \times 10^{-6}$
 $= 4 \times 3.14 \times 10^{-6} = 12.56 \times 10^{-6} = 1.26 \times 10^{-5} \text{ T}$



43. \vec{B} due to loop $\frac{\mu_0 i}{2r}$
 Let the straight current carrying wire be kept at a distance R from centre. Given $I = 4i$
 \vec{B} due to wire = $\frac{\mu_0 I}{2\pi R} = \frac{\mu_0 \times 4i}{2\pi R}$



Now, the \vec{B} due to both will balance each other

$$\text{Hence } \frac{\mu_0 i}{2r} = \frac{\mu_0 4i}{2\pi R} \Rightarrow R = \frac{4r}{\pi}$$

Hence the straight wire should be kept at a distance $4\pi/r$ from centre in such a way that the direction of current in it is opposite to that in the nearest part of circular wire. As a result the direction will \vec{B} will be oppose.

44. $n = 200$, $i = 2 \text{ A}$, $r = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$

$$(a) B = \frac{n\mu_0 i}{2r} = \frac{200 \times 4\pi \times 10^{-7} \times 2}{2 \times 10 \times 10^{-2}} = 2 \times 4\pi \times 10^{-4}$$

$$= 2 \times 4 \times 3.14 \times 10^{-4} = 25.12 \times 10^{-4} \text{ T} = 2.512 \text{ mT}$$

$$(b) B = \frac{n\mu_0 i a^2}{2(a^2 + d^2)^{3/2}} \Rightarrow \frac{n\mu_0 i}{4a} = \frac{n\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$$

$$\Rightarrow \frac{1}{2a} = \frac{a^2}{2(a^2 + d^2)^{3/2}} \Rightarrow (a^2 + d^2)^{3/2} 2a^3 \Rightarrow a^2 + d^2 = (2a^3)^{2/3}$$

$$\Rightarrow a^2 + d^2 = (2^{1/3} a)^2 \Rightarrow a^2 + d^2 = 2^{2/3} a^2 \Rightarrow (10^{-1})^2 + d^2 = 2^{2/3} (10^{-1})^2$$

$$\Rightarrow 10^{-2} + d^2 = 2^{2/3} 10^{-2} \Rightarrow (10^{-2})(2^{2/3} - 1) = d^2 \Rightarrow (10^{-2})(4^{1/3} - 1) = d^2$$

$$\Rightarrow 10^{-2}(1.5874 - 1) = d^2 \Rightarrow d^2 = 10^{-2} \times 0.5874$$

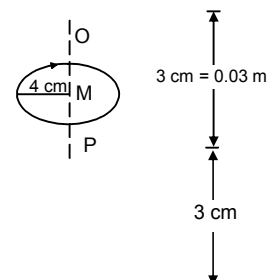
$$\Rightarrow d = \sqrt{10^{-2} \times 0.5874} = 10^{-1} \times 0.766 \text{ m} = 7.66 \times 10^{-2} = 7.66 \text{ cm.}$$

45. At O P the \vec{B} must be directed downwards
 We Know B at the axial line at O & P

$$= \frac{\mu_0 i a^2}{2(a^2 + d^2)^{3/2}} \quad a = 4 \text{ cm} = 0.04 \text{ m}$$

$$= \frac{4\pi \times 10^{-7} \times 5 \times 0.0016}{2(0.0025)^{3/2}} \quad d = 3 \text{ cm} = 0.03 \text{ m}$$

$$= 40 \times 10^{-6} = 4 \times 10^{-5} \text{ T} \quad \text{downwards in both the cases}$$



46. $q = 3.14 \times 10^{-6} \text{ C}$, $r = 20 \text{ cm} = 0.2 \text{ m}$,
 $w = 60 \text{ rad/sec.}$, $i = \frac{q}{t} = \frac{3.14 \times 10^{-6} \times 60}{2\pi \times 0.2} = 1.5 \times 10^{-5}$

$$\frac{\text{Electric field}}{\text{Magnetic field}} = \frac{\frac{xQ}{4\pi\epsilon_0(x^2 + a^2)^{3/2}}}{\frac{\mu_0 i a^2}{2(a^2 + x^2)^{3/2}}} = \frac{xQ}{4\pi\epsilon_0(x^2 + a^2)^{3/2}} \times \frac{2(x^2 + a^2)^{3/2}}{\mu_0 i a^2}$$

$$= \frac{9 \times 10^9 \times 0.05 \times 3.14 \times 10^{-6} \times 2}{4\pi \times 10^{-7} \times 15 \times 10^{-5} \times (0.2)^2}$$

$$= \frac{9 \times 5 \times 2 \times 10^3}{4 \times 13 \times 4 \times 10^{-12}} = \frac{3}{8}$$

47. (a) For inside the tube $\vec{B} = 0$

As, \vec{B} inside the conducting tube = 0

(b) For \vec{B} outside the tube

$$d = \frac{3r}{2}$$

$$\vec{B} = \frac{\mu_0 i}{2\pi d} = \frac{\mu_0 i \times 2}{2\pi 3r} = \frac{\mu_0 i}{2\pi r}$$

48. (a) At a point just inside the tube the current enclosed in the closed surface = 0.

$$\text{Thus } B = \frac{\mu_0 0}{A} = 0$$

(b) Taking a cylindrical surface just outside the tube, from ampere's law.

$$\mu_0 i = B \times 2\pi b \Rightarrow B = \frac{\mu_0 i}{2\pi b}$$

49. i is uniformly distributed throughout.

$$\text{So, 'i' for the part of radius } a = \frac{i}{\pi b^2} \times \pi a^2 = \frac{ia^2}{b^2} = I$$

Now according to Ampere's circuital law

$$\oint \vec{B} \times d\vec{l} = B \times 2 \times \pi \times a = \mu_0 I$$

$$\Rightarrow B = \mu_0 \frac{ia^2}{b^2} \times \frac{1}{2\pi a} = \frac{\mu_0 ia}{2\pi b^2}$$

50. (a) $r = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$
 $x = 2 \times 10^{-2} \text{ m}$, $i = 5 \text{ A}$
 i in the region of radius 2 cm

$$\frac{5}{\pi(10 \times 10^{-2})^2} \times \pi(2 \times 10^{-2})^2 = 0.2 \text{ A}$$

$$B \times \pi(2 \times 10^{-2})^2 = \mu_0(0.2)$$

$$\Rightarrow B = \frac{4\pi \times 10^{-7} \times 0.2}{\pi \times 4 \times 10^{-4}} = \frac{0.2 \times 10^{-7}}{10^{-4}} = 2 \times 10^{-4}$$

(b) 10 cm radius

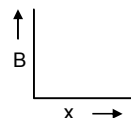
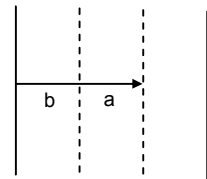
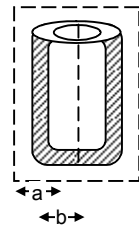
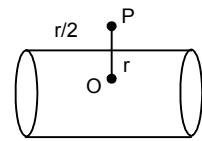
$$B \times \pi(10 \times 10^{-2})^2 = \mu_0 \times 5$$

$$\Rightarrow B = \frac{4\pi \times 10^{-7} \times 5}{\pi \times 10^{-2}} = 20 \times 10^{-5}$$

(c) $x = 20 \text{ cm}$

$$B \times \pi \times (20 \times 10^{-2})^2 = \mu_0 \times 5$$

$$\Rightarrow B = \frac{\mu_0 \times 5}{\pi \times (20 \times 10^{-2})^2} = \frac{4\pi \times 10^{-7} \times 5}{\pi \times 400 \times 10^{-4}} = 5 \times 10^{-5}$$



51. We know, $\int \mathbf{B} \times d\mathbf{l} = \mu_0 i$. Theoretically $B = 0$ at A

If, a current is passed through the loop PQRS, then

$$B = \frac{\mu_0 i}{2(\ell + b)}$$
 will exist in its vicinity.

Now, As the \vec{B} at A is zero. So there'll be no interaction

However practically this is not true. As a current carrying loop, irrespective of its near about position is always affected by an existing magnetic field.

52. (a) At point P, $i = 0$, Thus $B = 0$

(b) At point R, $i = 0$, $B = 0$

(c) At point θ ,

Applying ampere's rule to the above rectangle

$$B \times 2l = \mu_0 K_0 \int_0^l d\mathbf{l}$$

$$\Rightarrow B \times 2l = \mu_0 k l \Rightarrow B = \frac{\mu_0 k}{2}$$

$$B \times 2l = \mu_0 K_0 \int_0^l d\mathbf{l}$$

$$\Rightarrow B \times 2l = \mu_0 k l \Rightarrow B = \frac{\mu_0 k}{2}$$

Since the \vec{B} due to the 2 stripes are along the same direction, thus.

$$B_{\text{net}} = \frac{\mu_0 k}{2} + \frac{\mu_0 k}{2} = \mu_0 k$$

53. Charge = q , mass = m

We know radius described by a charged particle in a magnetic field B

$$r = \frac{mv}{qB}$$

But $B = \mu_0 K$ [according to Ampere's circuital law, where K is a constant]

$$r = \frac{mv}{q\mu_0 k} \Rightarrow v = \frac{rq\mu_0 k}{m}$$

54. $i = 25$ A, $B = 3.14 \times 10^{-2}$ T, $n = ?$

$$B = \mu_0 n i$$

$$\Rightarrow 3.14 \times 10^{-2} = 4 \times \pi \times 10^{-7} n \times 5$$

$$\Rightarrow n = \frac{10^{-2}}{20 \times 10^{-7}} = \frac{1}{2} \times 10^4 = 0.5 \times 10^4 = 5000 \text{ turns/m}$$

55. $r = 0.5$ mm, $i = 5$ A, $B = \mu_0 n i$ (for a solenoid)

Width of each turn = 1 mm = 10^{-3} m

$$\text{No. of turns 'n'} = \frac{1}{10^{-3}} = 10^3$$

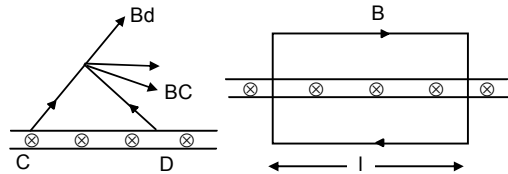
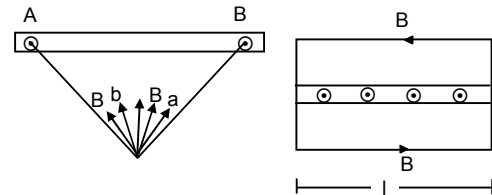
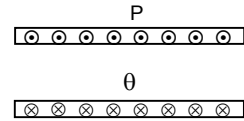
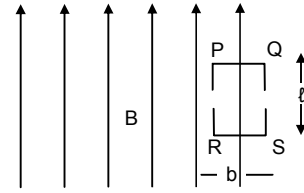
$$\text{So, } B = 4\pi \times 10^{-7} \times 10^3 \times 5 = 2\pi \times 10^{-3} \text{ T}$$

56. $\frac{R}{l} = 0.01 \Omega$ in 1 m, $r = 1.0$ cm, Total turns = 400, $\ell = 20$ cm,

$$B = 1 \times 10^{-2} \text{ T}, \quad n = \frac{400}{20 \times 10^{-2}} \text{ turns/m}$$

$$i = \frac{E}{R_0} = \frac{E}{R_0 / l \times (2\pi r \times 400)} = \frac{E}{0.01 \times 2 \times \pi \times 0.01 \times 400}$$

$$B = \mu_0 n i$$



$$\Rightarrow 10^2 = 4\pi \times 10^{-7} \times \frac{400}{20 \times 10^{-2}} \times \frac{E}{400 \times 2\pi \times 0.01 \times 10^{-2}}$$

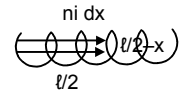
$$\Rightarrow E = \frac{10^{-2} \times 20 \times 10^{-2} \times 400 \times 2\pi \times 10^{-2} \times 0.01}{4\pi \times 10^{-7} \times 400} = 1 \text{ V}$$

57. Current at '0' due to the circular loop = $dB = \frac{\mu_0}{4\pi} \times \frac{a^2 \sin x}{\left[a^2 + \left(\frac{l}{2} - x \right)^2 \right]^{3/2}}$

\therefore for the whole solenoid $B = \int_0^B dB$

$$= \int_0^l \frac{\mu_0 a^2 n dx}{4\pi \left[a^2 + \left(\frac{l}{2} - x \right)^2 \right]^{3/2}}$$

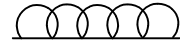
$$= \frac{\mu_0 n i}{4\pi} \int_0^l \frac{a^2 dx}{a^3 \left[1 + \left(\frac{l - 2x}{2a} \right)^2 \right]^{3/2}} = \frac{\mu_0 n i}{4\pi a} \int_0^l \frac{dx}{\left[1 + \left(\frac{l - 2x}{2a} \right)^2 \right]^{3/2}} = 1 + \left(\frac{l - 2x}{2a} \right)^2$$



58. $i = 2 \text{ A}$, $f = 10^8 \text{ rev/sec}$, $n = ?$, $m_e = 9.1 \times 10^{-31} \text{ kg}$,
 $q_e = 1.6 \times 10^{-19} \text{ C}$, $B = \mu_0 n i \Rightarrow n = \frac{B}{\mu_0 i}$

$$f = \frac{qB}{2\pi m_e} \Rightarrow B = \frac{f 2\pi m_e}{q_e} \Rightarrow n = \frac{B}{\mu_0 i} = \frac{f 2\pi m_e}{q_e \mu_0 i} = \frac{10^8 \times 9.1 \times 10^{-31}}{1.6 \times 10^{-19} \times 2 \times 10^{-7} \times 2 \text{ A}} = 1421 \text{ turns/m}$$

59. No. of turns per unit length = n , radius of circle = $r/2$, current in the solenoid = i ,
 Charge of Particle = q , mass of particle = m $\therefore B = \mu_0 n i$



Again $\frac{mV^2}{r} = qVB \Rightarrow V = \frac{qBr}{m} = \frac{q\mu_0 n i r}{2m} = \frac{\mu_0 n i q r}{2m}$

60. No. of turns per unit length = ℓ
 (a) As the net magnetic field = zero

$$\therefore \vec{B}_{\text{plate}} = \vec{B}_{\text{solenoid}}$$

$$\vec{B}_{\text{plate}} \times 2\ell = \mu_0 k \ell = \mu_0 k \ell$$

$$\vec{B}_{\text{plate}} = \frac{\mu_0 k}{2} \quad \dots(1)$$

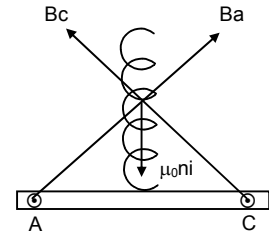
$$\vec{B}_{\text{solenoid}} = \mu_0 n i \quad \dots(2)$$

Equating both $i = \frac{\mu_0 k}{2}$

(b) $B_a \times \ell = \mu_0 k \Rightarrow B_a = \mu_0 k \quad B_c = \mu_0 k$

$$B = \sqrt{B_a^2 + B_c^2} = \sqrt{2(\mu_0 k)^2} = \sqrt{2} \mu_0 k$$

$$2 \mu_0 k = \mu_0 n i \quad i = \frac{\sqrt{2} k}{n}$$



61. $C = 100 \mu\text{F}$, $Q = CV = 2 \times 10^{-3} \text{ C}$, $t = 2 \text{ sec}$,
 $V = 20 \text{ V}$, $V' = 18 \text{ V}$, $Q' = CV = 1.8 \times 10^{-3} \text{ C}$,
 $\therefore i = \frac{Q - Q'}{t} = \frac{2 \times 10^{-3} - 1.8 \times 10^{-3}}{2} = 10^{-4} \text{ A}$ $n = 4000 \text{ turns/m}$.
 $\therefore B = \mu_0 n i = 4\pi \times 10^{-7} \times 4000 \times 10^{-4} = 16 \pi \times 10^{-7} \text{ T}$