

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

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

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

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

Along +ve Y direction.

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

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

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

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

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

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

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

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

$$r = 2 \text{ cm} = 0.02 \text{ m,}$$

$$I = 1 \text{ A,}$$

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

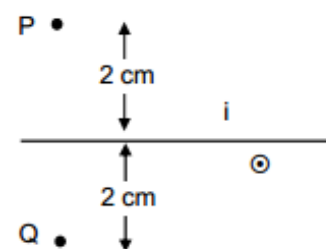
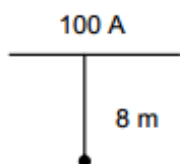
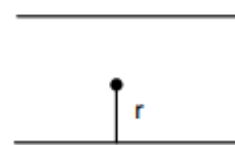
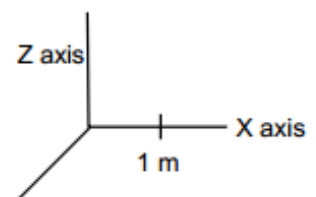
We know: Magnetic field due to a long straight wire carrying current =  $\frac{\mu_0 I}{2\pi r}$

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

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

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

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



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

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

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

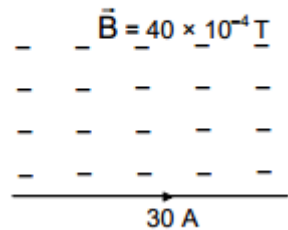
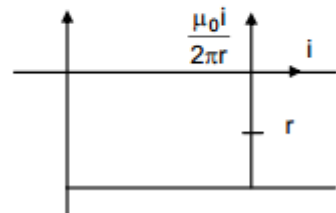
$$r > \frac{\mu_0 I}{2\pi B} \quad B_{\text{net}} = B - \frac{\mu_0 I}{2\pi r}$$

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

$\vec{B}$  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

$$R = OA_1 = \sqrt{(0.02)^2 + (0.02)^2} = \sqrt{8 \times 10^{-4}} = 2.828 \times 10^{-2} \text{ m}$$

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

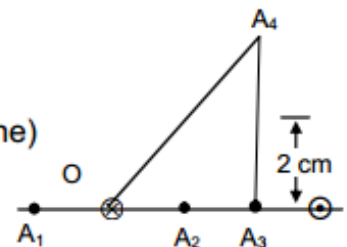
$\vec{B}$  due to P, at  $A_1 = \frac{4\pi \times 10^{-7} \times 10}{2\pi \times 0.06} = 0.33 \times 10^{-4} \text{ T } (\perp r \text{ towards down the line})$

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  $A_2 = \frac{2 \times 10^{-7} \times 10}{0.01} = 2 \times 10^{-4} \text{ T } \quad \perp r \text{ down the line}$

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

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  $O = 1 \times 10^{-4} \text{ T}$   $\perp r$  towards down the line  
 $\vec{B}$  at  $A_3$  due to  $P = 1 \times 10^{-4} \text{ T}$   $\perp r$  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  $X$  both directed along  $Z$ -axis

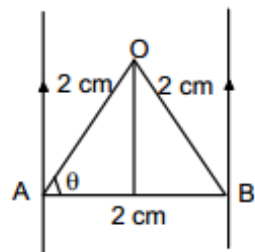
Net  $\vec{B} = \frac{2 \times 10^{-7} \times 2 \times 5}{1} = 2 \times 10^{-6} \text{ T} = 2 \mu\text{T}$

(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  $Q_1$

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

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

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

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

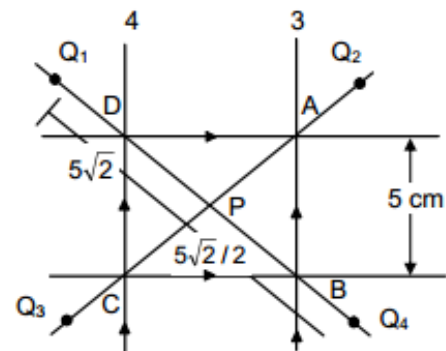
$$B_{\text{net}} = [4 + 4 + (4/3) + (4/3)] \times 10^{-5} = \frac{32}{3} \times 10^{-5} = 10.6 \times 10^{-5} \approx 1.1 \times 10^{-4} \text{ T}$$

At point  $Q_2$

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

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

$$\text{due to (3) } \frac{\mu_0 i}{2\pi \times (5 + 5/2) \times 10^{-2}} \otimes$$



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

At point  $Q_3$

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

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

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

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

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

For  $Q_4$

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

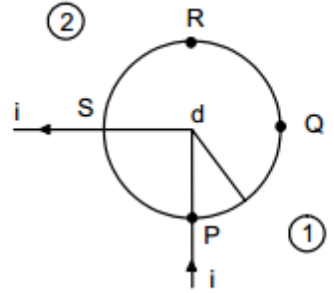
$$\text{due to (2)} 4 \times 10^{-5} \quad \otimes$$

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

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

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

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  $\vec{B} = \frac{\pi_0 i}{4\pi d}$



At P  
 $B_1$  due to 1 is 0  
 $B_2$  due to 2 is  $\frac{\pi_0 i}{4\pi d}$

At Q  
 $B_1$  due to 1 is  $\frac{\pi_0 i}{4\pi d}$   
 $B_2$  due to 2 is 0

At R  
 $B_1$  due to 1 is 0  
 $B_2$  due to 2 is  $\frac{\pi_0 i}{4\pi d}$

At S  
 $B_1$  due to 1 is  $\frac{\pi_0 i}{4\pi d}$   
 $B_2$  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.  $d$

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

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

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

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

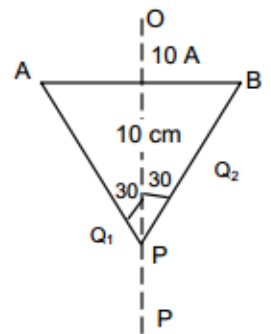
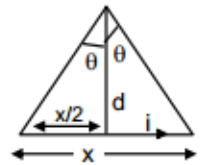
$$\therefore B \propto \frac{1}{d}$$

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

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

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

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





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

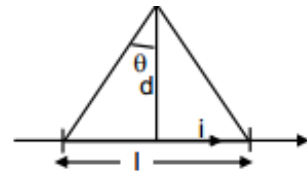
$$B_1 - B_2 = \frac{1}{100} B_2 \Rightarrow \frac{\mu_0 i}{2\pi d} - \frac{\mu_0 i \ell}{4\pi d \sqrt{d^2 + \frac{\ell^2}{4}}} = \frac{\mu_0 i}{200\pi d}$$

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

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

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

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

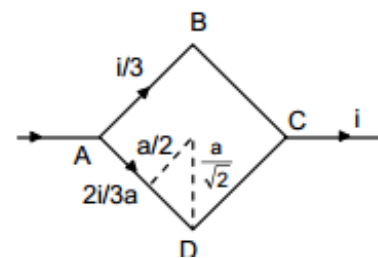


17. As resistances vary as  $r$  &  $2r$

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

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

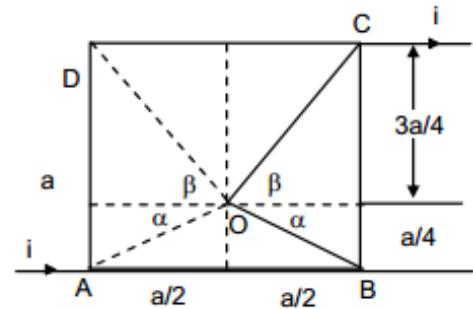
$$\begin{aligned} B_{AB} &= \frac{\mu_0}{4\pi} \times \frac{i}{2(a/4)} (\sin(90 - i) + \sin(90 - \alpha)) \\ &= \frac{\mu_0 \times 2i}{4\pi a} 2\cos\alpha = \frac{\mu_0 \times 2i}{4\pi a} \times 2 \times \frac{(a/2)}{a(\sqrt{5}/4)} = \frac{2\mu_0 i}{\pi\sqrt{5}} \end{aligned}$$

Magnetic field due to DC

$$\begin{aligned} B_{DC} &= \frac{\mu_0}{4\pi} \times \frac{i}{2(3a/4)} 2\sin(90^\circ - \beta) \\ &= \frac{\mu_0 i \times 4 \times 2}{4\pi \times 3a} \cos\beta = \frac{\mu_0 i}{\pi \times 3a} \times \frac{(a/2)}{(\sqrt{13}a/4)} = \frac{2\mu_0 i}{\pi a 3\sqrt{13}} \end{aligned}$$

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

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



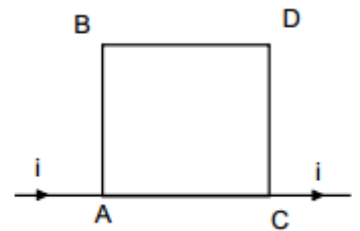
19.  $\vec{B}$  due to BC &

$\vec{B}$  due to AD at Pt 'P' are equal or 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.



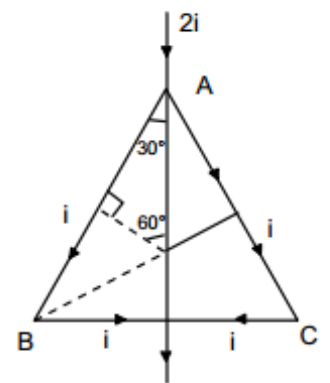
20. For AB  $B$  is along  $\odot$   $B = \frac{\mu_0 i}{4\pi r} (\sin 60^\circ + \sin 60^\circ)$

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

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

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

$\therefore$  Net  $B = 0$



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

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

Current =  $i$

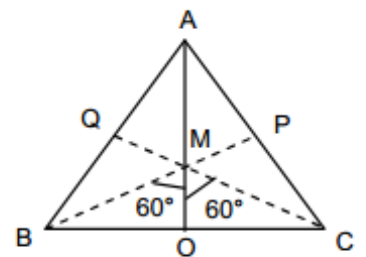
$$AO = \frac{\sqrt{3}}{2} a = \frac{\sqrt{3} \times \ell}{2 \times 3} = \frac{\ell}{2\sqrt{3}}$$

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

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

$\vec{B}$  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

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

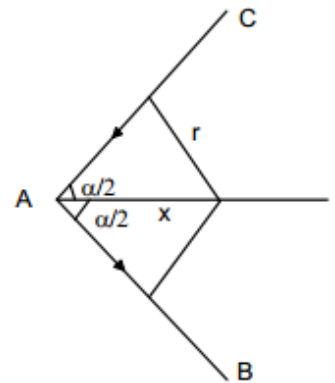
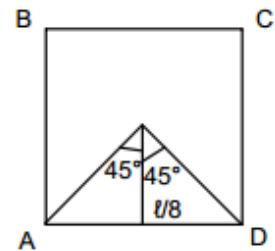
$$\Rightarrow \frac{\mu_0 i [\sin(90 - (\alpha/2)) + 1]}{4\pi \times \sin(\alpha/2)}$$

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

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

The magnetic field due to both the wire.

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

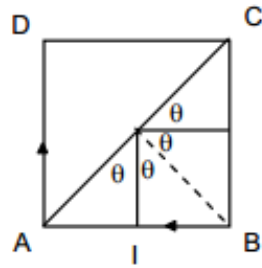


23.  $\vec{B}_{AB}$

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

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

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



$\vec{B}_{BC}$

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

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

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

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

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

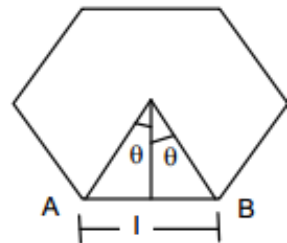
$$\tan \theta = \frac{\ell}{2x} \Rightarrow x = \frac{\ell}{2 \tan \theta}$$

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

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

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

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



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  $2 \times 10^{-5}$  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.  $i = 10$  A

Magnetic force due to two parallel Current Carrying wires.

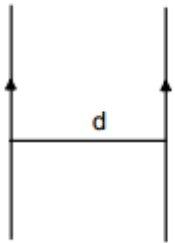
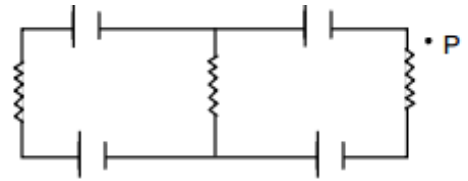
$$F = \frac{\mu_0 I_1 I_2}{2\pi r}$$

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

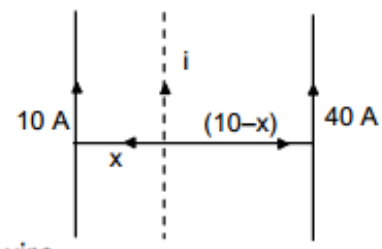
$$= \frac{\mu_0 \times 10 \times 10}{2\pi \times 5 \times 10^{-2}} + \frac{\mu_0 \times 10 \times 10}{2\pi \times 10 \times 10^{-2}}$$

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

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

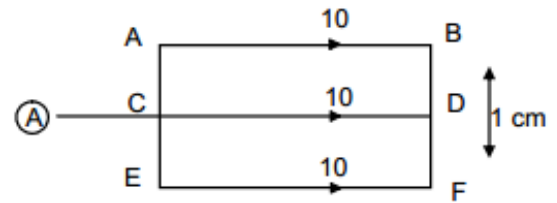


28.  $\frac{\mu_0 10i}{2\pi x} = \frac{\mu_0 i 40}{2\pi(10-x)}$   
 $\Rightarrow \frac{10}{x} = \frac{40}{10-x} \Rightarrow \frac{1}{x} = \frac{4}{10-x}$   
 $\Rightarrow 10-x = 4x \Rightarrow 5x = 10 \Rightarrow x = 2 \text{ cm}$



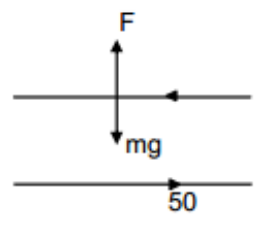
The third wire should be placed 2 cm from the 10 A wire and 8 cm from 40 A wire.

29.  $F_{AB} = F_{CD} + F_{EF}$   
 $= \frac{\mu_0 \times 10 \times 10}{2\pi \times 1 \times 10^{-2}} + \frac{\mu_0 \times 10 \times 10}{2\pi \times 2 \times 10^{-2}}$   
 $= 2 \times 10^{-3} + 10^{-3} = 3 \times 10^{-3}$  downward.



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

30.  $\frac{\mu_0 i_1 i_2}{2\pi d} = mg$  (For a portion of wire of length 1m)  
 $\Rightarrow \frac{\mu_0 \times 50 \times i_2}{2\pi \times 5 \times 10^{-3}} = 1 \times 10^{-4} \times 9.8$   
 $\Rightarrow \frac{4\pi \times 10^{-7} \times 5 \times i_2}{2\pi \times 5 \times 10^{-3}} = 9.8 \times 10^{-4}$   
 $\Rightarrow 2 \times i_2 \times 10^{-3} = 9.8 \times 10^{-3} \times 10^{-1}$   
 $\Rightarrow i_2 = \frac{9.8}{2} \times 10^{-1} = 0.49 \text{ A}$



31.  $I_2 = 6 \text{ A}$   
 $I_1 = 10 \text{ A}$

$F_{PQ}$

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

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

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

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

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

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

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

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

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

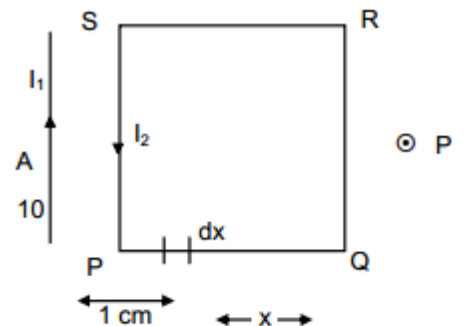
Net force towards down

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

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.  $3 \times 10^5$  revolutions in 1 sec.

1 revolutions in  $\frac{1}{3 \times 10^5}$  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.  $r_1 = 5 \text{ cm}$

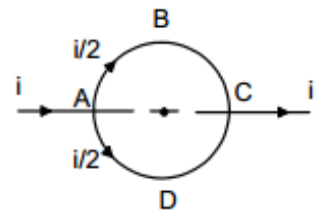
$r_2 = 10 \text{ cm}$

$n_1 = 50$

$n_2 = 100$

$i = 2 \text{ A}$

(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

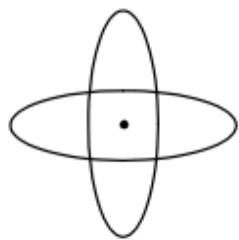
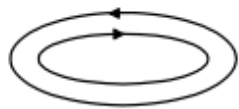
$$\text{Net } B = \sqrt{(4\pi \times 10^{-4})^2 + (4\pi \times 10^{-4})^2} = \sqrt{32\pi^2 \times 10^{-8}} = 17.7 \times 10^{-4} \approx 18 \times 10^{-4} = 1.8 \times 10^{-3} = 1.8 \text{ mT}$$

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

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

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

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



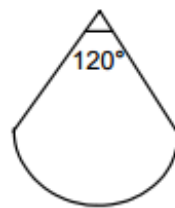
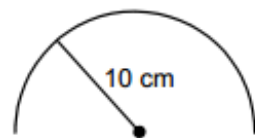
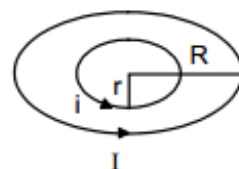
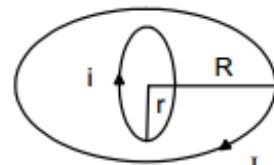
39.  $\vec{B}$  Large loop =  $\frac{\mu_0 I}{2R}$   
 'i' due to larger loop on the smaller loop  
 $= i(A \times B) = i AB \sin 90^\circ = i \times \pi r^2 \times \frac{\mu_0 I}{2R}$

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

43.  $\vec{B}$  due to loop  $\frac{\mu_0 i}{2r}$



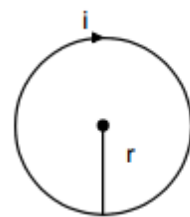
Let the straight current carrying wire be kept at a distance  $R$  from centre. Given  $I = 4i$

$$\vec{B} \text{ due to wire} = \frac{\mu_0 I}{2\pi R} = \frac{\mu_0 \times 4i}{2\pi R}$$

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  $4r/\pi$  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.  $n = 200$ ,  $i = 2 \text{ A}$ ,  $r = 10 \text{ cm} = 10 \times 10^{-2} \text{ m}$

$$\begin{aligned} \text{(a) } B &= \frac{n\mu_0 i}{2r} = \frac{200 \times 4\pi \times 10^{-7} \times 2}{2 \times 10 \times 10^{-2}} = 2 \times 4\pi \times 10^{-4} \\ &= 2 \times 4 \times 3.14 \times 10^{-4} = 25.12 \times 10^{-4} \text{ T} = 2.512 \text{ mT} \end{aligned}$$

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

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

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

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

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

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

45. At O P the  $\vec{B}$  must be directed downwards

We Know  $B$  at the axial line at O & P

$$= \frac{\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$$

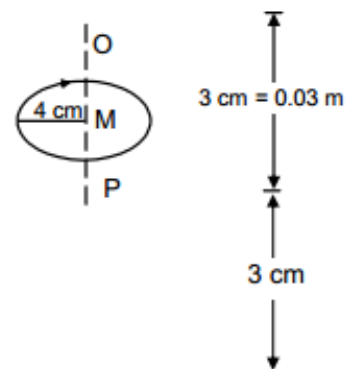
$$= \frac{4\pi \times 10^{-7} \times 5 \times 0.0016}{2((0.0025)^{3/2})}$$

$$= 40 \times 10^{-6} = 4 \times 10^{-5} \text{ T}$$

$$a = 4 \text{ cm} = 0.04 \text{ m}$$

$$d = 3 \text{ cm} = 0.03 \text{ m}$$

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

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

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

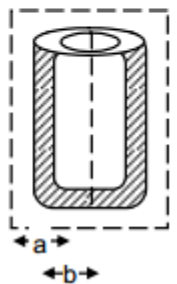
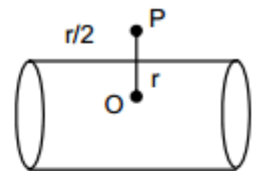
48. (a) At a point just inside the tube the current enclosed in the closed surface = 0.

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

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

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

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

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

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

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

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

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

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

(b) 10 cm radius

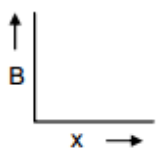
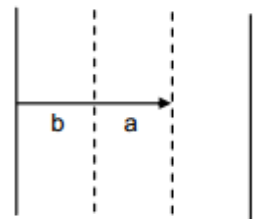
$$\mathbf{B} \times \pi(10 \times 10^{-2})^2 = \mu_0 \times 5$$

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

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

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

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



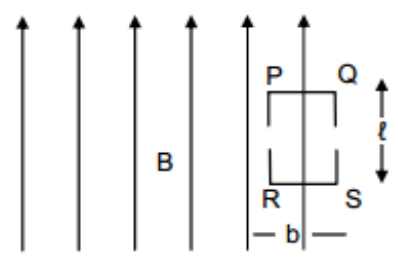
51. We know,  $\int \mathbf{B} \times d\mathbf{l} = \mu_0 i$ . Theoretically  $B = 0$  at A

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

$$B = \frac{\mu_0 i}{2(\ell + b)}$$

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  $\theta$ ,

Applying ampere's rule to the above rectangle

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

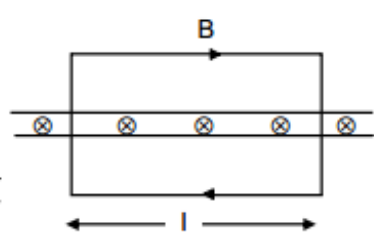
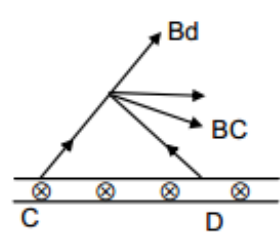
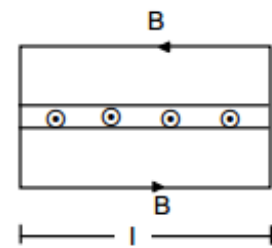
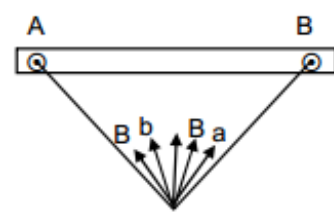
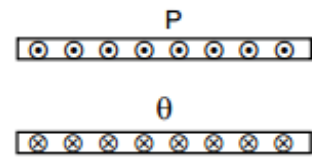
$$\Rightarrow B \times 2l = \mu_0 k l \Rightarrow B = \frac{\mu_0 k}{2}$$

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

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

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

$$B = \mu_0 ni$$

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

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

55.  $r = 0.5 \text{ mm}$ ,  $i = 5 \text{ A}$ ,  $B = \mu_0 ni$  (for a solenoid)

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

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

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

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

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

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

$$B = \mu_0 ni$$



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

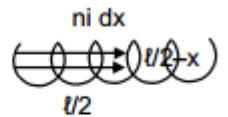
$$\Rightarrow E = \frac{10^{-2} \times 20 \times 10^{-2} \times 400 \times 2\pi \times 10^{-2} \times 0.01}{4\pi \times 10^{-7} \times 400} = 1 \text{ V}$$

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

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

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

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



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 =  $m$   $\therefore B = \mu_0 ni$

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



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

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

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

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

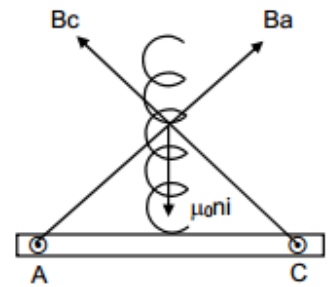
$$\vec{B}_{\text{Solenoid}} = \mu_0 ni \quad \dots(2)$$

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

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

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

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



61.  $C = 100 \mu\text{f}$ ,  $Q = CV = 2 \times 10^{-3} \text{ C}$ ,  $t = 2 \text{ sec}$ ,  
 $V = 20 \text{ V}$ ,  $V' = 18 \text{ V}$ ,  $Q' = CV = 1.8 \times 10^{-3} \text{ C}$ ,

$$\therefore i = \frac{Q - Q'}{t} = \frac{2 \times 10^{-4}}{2} = 10^{-4} \text{ A} \quad n = 4000 \text{ turns/m.}$$

$$\therefore B = \mu_0 ni = 4\pi \times 10^{-7} \times 4000 \times 10^{-4} = 16\pi \times 10^{-7} \text{ T}$$