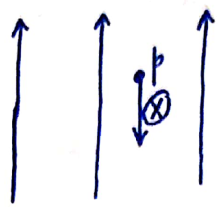
MAGNETOSTATS

**Q.** A unit magnetic field 1.5 $Wb/m^2$ points horizontally from south to north. A proton of energy 5.0 MeV moves vertically downward through this field. Calculate the force on it.



$\sqrt{2 \times 5 \times 10^6 \times (1.6 \times 10^{-19})} = v$

$\therefore \quad K = 5 \times 10^6 eV$

$\therefore \quad p = \sqrt{2km}$

and $\quad F_B = qVB\sin\theta$

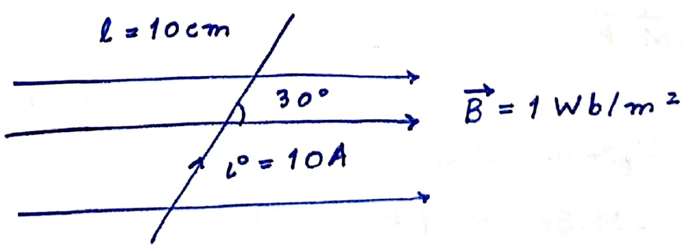
$= 1.6 \times 10^{-19} \times \frac{mv}{m} \times 1.5 \times \sin 90^\circ$

$= 1.6 \times 10^{-19} \times \frac{\sqrt{2km}}{m} \times 1.5 \times 1$

$= 1.6 \times 10^{-19} \times \sqrt{\frac{2 \times 5 \times 10^6 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-27}}} \times 1.5$

$F_B = 7.58 \times 10^{-12}$ N Ans.

**Q.** A 10 cm long wire carrying a current of 10A is held at an angle 30° with a direction of a uniform magnetic field of strength 1 $Wb/m^2$. Calculate the force acting on the wire.

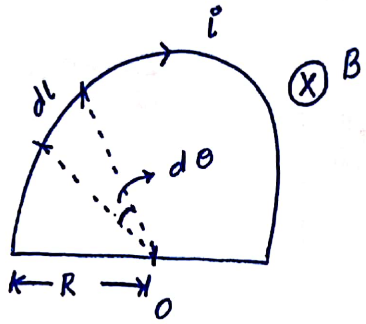



$\therefore \quad F = iLB\sin\theta$

$= 10 \times \frac{10}{100} \times 1 \times \sin 30^\circ$

$F = \frac{1}{2} = 0.5$ N Ans.

Q3. A semi-circular wire of radius 'R' m carries a current 1 A and is placed in a uniform field of 'B' Wb/m² acting ⊥ʳ to the plane of the semi-circle. Calculate the force acting on the wire.




∴ $dl = R\,d\theta$

∴ Force due to small element 'dl'

∴ $dF = i\,dl\,B \sin 90°$

$dF = 1 \times R\,d\theta\,B$

$\int dF = \int B R\,d\theta$

$F = BR \int_0^{\pi} d\theta$

$F = \pi B R$ N  Ans.

Q. A circular coil of 100 turns have an effective radius 50 cm and carries a current 0.10 A. Calculate the work done required to turn it in an external uniform magnetic field 1.5 Wb/m² through 180°.

∴ Magnetic moment : $M = NIA$

$\Rightarrow \quad M = 100 \times 0.10 \times \pi \left(\frac{50}{100}\right)^2 = 7.85\ \text{Am}^2$

∴ $W = -\vec{M} \cdot \vec{B}$

∴ $W = U_{final} - U_{initial}$  $\theta_1 = 0°$, $\theta_2 = 180°$

$= -MB\cos\theta_2 + MB\cos\theta_1$

$= MB[\cos\theta_1 - \cos\theta_2]$

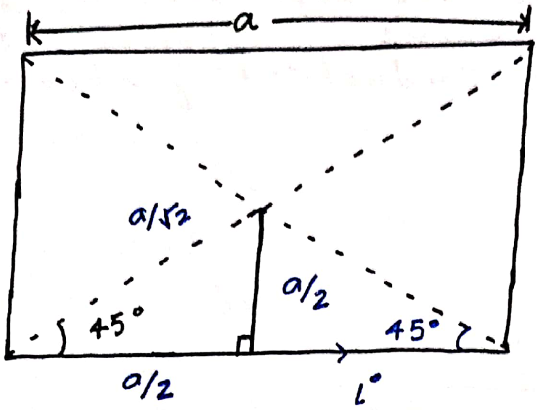
$= 7.85 \times 1.5[1 - (-1)]$

$W = 7.85 \times 3$

$W = 15.707$ J  Ans.

Q.

Find the magnetic induction square current loop.




$\therefore \frac{a^2}{2} = \frac{a^2}{4} + x^2$

$x^2 = a^2\left[\frac{1}{2} - \frac{1}{4}\right]$

$x = \frac{a}{2}$

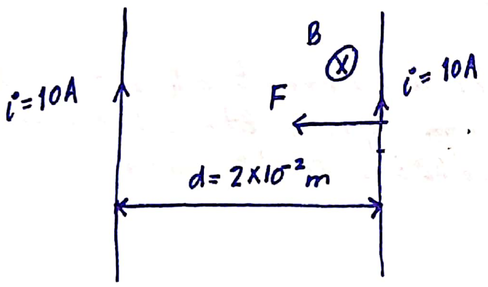
$\therefore$ Force due to finite wire $= \frac{\mu_0 i}{4\pi d}(\cos\theta_1 + \cos\theta_2)$

$= \frac{\mu_0 \times i \times 2}{4 \times \pi \times a}(\cos 45° + \cos 45°)$

$= \frac{\mu_0 i}{2\pi a} \times \frac{2}{\sqrt{2}}$

$F = \frac{\mu_0 i}{\sqrt{2}\pi a}$ N Ans.

Q. A current of 10A in each of the two conducting wires parallel to each other, the seperation between the wire is two centimeter. Find the force per unit length of one of the wires, will it be force of attraction or repulsion.




$\therefore F = \frac{\mu_0 i_1 i_2 l}{2\pi d}$

$\frac{\mu_0}{4\pi} = 10^{-7}$

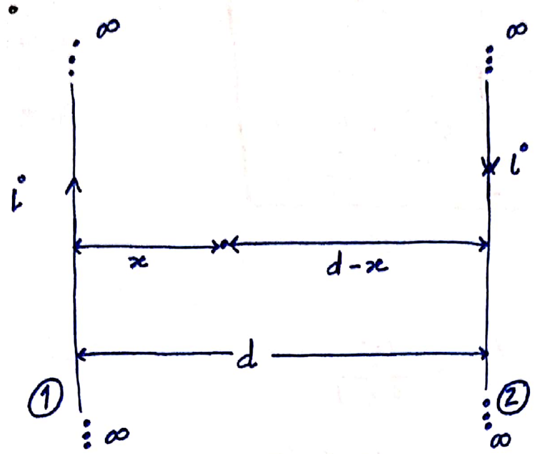
$\therefore \frac{F}{l} = \frac{\mu_0 \times 10 \times 10}{2 \times \pi \times 10^{-2}}$

$\Rightarrow \frac{F}{l} = 2 \times 10^{-7} \times 10^2 \times 10^2 = 2 \times 10^{-3}$ N/m Ans

$= 2$ mN/m Ans

Force will be ~~repulsive~~ attractive

Q. Two parallel wires are seperated by distance 'd' carrying equal current in opposite direction. Find the magnetic induction for point between the wire.




$$\therefore \quad B_1 = \frac{\mu_0 i}{2\pi x} \quad (\times)$$

$$B_2 = \frac{\mu_0 i}{2\pi(d-x)} \quad (\times)$$

$$\Rightarrow \quad B_{net} = \frac{\mu_0 i}{2\pi}\left[\frac{d-\cancel{x}+\cancel{x}}{x(d-x)}\right]$$

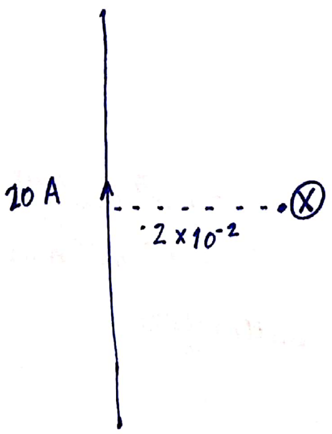
$$B_{net} = \frac{\mu_0 i d}{2\pi x(d-x)} \quad \text{Ans.}$$

Q. A long straight wire carries a current of 20 A. An electron is travelling is $10^7$ m/s. It is 2 cm from the wire. What force acts on the electron if it's motion is directed.

(i) Towards the wire

(ii) Parallel to the wire

(iii) At ring angle to the direction given in 'a' and 'b'.




$$\therefore \quad B = \frac{\mu_0 I}{2\pi d} = \frac{\cancel{4}\cancel{\pi}\times10^{-7}\times 20}{\cancel{2}\times\cancel{\pi}\times\cancel{2}\times10^{-2}}$$

$$= 2\times10^{-7+3}$$

$$B = 2\times10^{-4}\ T$$

$\therefore$ (a) if $e^{\ominus}$ moves towards the wire

$\Rightarrow \theta = 90^\circ$

$$\therefore \quad F = qVB = 1.6\times10^{-19}\times10^{7}\times2\times10^{-4}$$

$$= 3.2\times10^{-16} N$$

Q. A vertical cable line

(b) If $e^{\ominus}$ is parallel to wire

$\theta = 0°$

$\therefore$ $F = qVB\sin 0° = 0$

(c) If $e^{\ominus}$ is moving at right angle

$\theta = 90°$

$\therefore$ $F = 1.6\times10^{-19} \times 10^{7} \times 2\times10^{-4} \times \sin 90°$

$F = 3.2\times10^{-17}$ N Ans.

Q. A solenoid is 1 m long and 3 cm in mean diameter it has 5 layers of binding of 850 turns each and carries a current of 5A. Calculate the 'B' at it's centre.

$\therefore$ $B = \mu_0 n I$

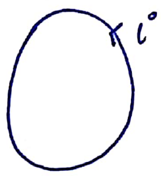
$n = \frac{N}{l} = \frac{5\times850}{1} = 4250$

$\therefore$ $B = (4\pi\times10^{-7}) \times 4250 \times 5$

$B = 0.0267$ T Ans.

Q. The electron circulate around the nucleus in a path of radius $5.1\times10^{-11}$ m at a frequency of $6.8\times10^{-15}$ revolutions per second. Calculate 'B' at the centre and magnetic dipole moment.

Magnetic field due to circular loop




$B = \frac{\mu_0 I}{2R}$

$\therefore$ $i = qf = 1.6\times10^{-19} \times 6.8\times10^{-15} = 1.088\times10^{-33}$ A

$\therefore$ $B = \frac{4\pi\times10^{-7} \times 1.088\times10^{-33}}{2 \times 5.1\times10^{-11}} = 1.34\times10^{-29}$ T

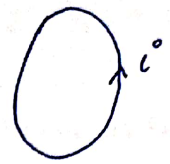
$\therefore$ $M = IA$

$= 1.088\times10^{-33} \times (\pi\,(5.1\times10^{-11})^2)$

$M = 8.89\times10^{-54}$ $Am^2$ Ans

Q. Find an expression for the magnetic induction at the centre of a circular current loop.

∴ Using Biot-Savart's law




$$dB = \frac{\mu_0}{4\pi} \frac{I\,dl \sin\theta}{r^2}$$

$(\theta = 90^\circ)$

$\sin 90^\circ = 1$

$$\therefore \quad dB = \frac{\mu_0}{4\pi} \frac{I\,dl}{r^2}$$

$$\int dB = \frac{\mu_0 I}{4\pi r^2} \int_0^{2\pi R} dl$$

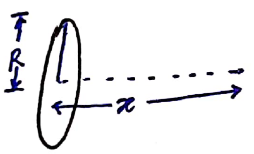
$$B = \frac{\mu_0 I}{4\pi r^2} \cdot 2\pi r$$

$$B = \frac{\mu_0 I}{2r} \quad \text{Ans}$$

Q. Two similar coils of wire having a radius of 7 cm and 60 turns have a common axis and are ~~6~~ 18 cm apart. Find the strength of the magnetic field at a point midway between them on their common axis. when a current of 0.1 A is passed through them.

$\therefore \; x = \frac{18}{2} = 9\,\text{cm}$

Because $\vec{B}$ is asked at midway (midpoint).




$$\therefore \quad \vec{B} \text{ due to coil} = \frac{\mu_0 N I R^2}{2(R^2 + x^2)^{3/2}}$$

$$\therefore \quad \vec{B}_{Total} = \frac{4\pi \times 10^{-7} \times 60 \times 0.1 \times (7\times10^{-2})^2}{2\left((7\times10^{-2})^2 + (9\times10^{-2})^2\right)^{3/2}}$$

$$= 5.1\,mT \quad \text{Ans}$$

These handwritten notes are of PHY-S102 taught to us by Prof. Prabal Pratap Singh, compiled and organized chapter-wise to help our juniors. We hope they make your prep a bit easier.

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