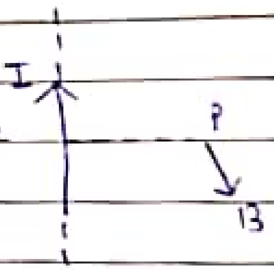
Moving Charges And Magnetism

1. Here $n = 100$, $r = 8cm = 8\times10^{-2}$ cm
$I = 0.40A$.

The magnetic field B at the centre
$$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I n}{r} = \frac{10^{-7}\times2\times3.14\times0.4\times100}{8\times10^{-2}}$$
$$= 3.1\times10^{-4} T$$
The direction of magnetic field depends of the direction of current if the direction of current is anticlockwise Acc. to Maxwell's right hand rule, the direction of magnetic field at the centre of coil will be perpendicular outwards to the plane of paper.

2. Here, we have to find the magnetic field at point P.
$I = 35A$ and $r = 20cm = 0.2m$
The wire is long and it is considered as an infinite length wire. The magnetic field



$$B = \frac{\mu_0}{4\pi} \cdot \frac{2I}{r} = \frac{10^{-7}\times2\times35}{0.2} = 3.5\times10^{-5} T$$
The direction of magnetic field given by maxwell's right hand rule current is upward, magnetic field at P is ⊥ inwards to the plane of paper.

6. Here, the angle betn the magnetic field and the direction of flow of current is 90°. Because the magnetic field due to a solenoid is along the axis of the solenoid and the wire is placed ⊥ to the axis
Given, $l = 3cm = 3\times10^{-2}$ cm, $I = 10A$, $B = 0.27$
The magnitude of magnetic force on the wire
$$F = IlB\sin90° = 10\times3\times10^{-2}\times0.27\times\sin90° = 8.1\times10^{-2} N.$$

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Acc. to right hand palm rule, the direction of magnetic force is $\perp$ to plane of paper inwards.

7. Given, $I_1 = 8A$, $I_2 = 5A$ and $r = 4cm = 0.04m$
Force per unit length on two parallel wire carrying current.

$$F = \frac{\mu_0}{4\pi} \cdot \frac{2I_1 \cdot I_1}{r}$$

$$= \frac{10^{-7} \times 2 \times 8 \times 5}{0.04} = 2 \times 10^{-4} N.$$

The force on A of length 10cm is $F' = F \times 0.1$
$F' = 2 \times 10^{-4} \times 0.1$
$= 2 \times 10^{-5} N.$

8. The length of solenoid $= l = 80cm = 0.8m$.
No. of layer $= 5$
No. of turns per layer $= 400$
Diameter of solenoid $= 1.8cm$
Current in solenoid $I = 8A$.
$\therefore$ Total number of turns $N = 400 \times 5 = 2000$
and number of turns/length $n = \frac{2000}{0.8} = 2500$.
The magnitude of magnetic field inside the solenoid
$B = \mu_0 n I = 4 \times 3.14 \times 10^{-7} \times 2500 \times 8 = 2.5 \times 10^{-2} T$.

11. Given, magnetic field
$B = 6.5 G = 6.5 \times 10^{-4} T$
Charge $e = -1.6 \times 10^{-19} C$.
Speed of electron $v = 4.8 \times 10^{6} m/s$
Mass of e^- $m_e = 9.1 \times 10^{-31} kg$
Angle betn magnetic field and electron $\theta = 90°$

The force on the charge particle entering in the magnetic field

$$F = q(V \times B) = e(V \times B)$$

Acc. the right hand palm rule, the direction of force is perpendicular to both velocity and magnetic field.

i.e., the force will only change the direction of motion without changing the magnitude of velocity. So the electron attains a circular path and the necessary centripetal force is provided by the magnetic force.

$$e(V \times B) = \frac{mv^2}{r}$$

$$evB\sin 90^\circ = \frac{mv^2}{r}$$

$$r = \frac{mv}{eB \times 1} = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{1.6 \times 10^{-19} \times 6.5 \times 10^{-4}} = 4.2 \times 10^{-2} m = 4.2 cm$$

12. Given, $B = 6.5 G = 6.5 \times 10^{-4} T$

$v = 4.8 \times 10^{6} m/s$, $e = 1.6 \times 10^{-19} c$

$m_e = 9.1 \times 10^{-31} kg$

When a e^- (Charged particle) moves on a circular path in uniform magnetic field then the required centripetal force is provided by the magnetic force on it.

$$\frac{mv^2}{r} = qvB \quad \frac{mv}{r} = qB$$

If angular velocity of e^- is ω, then

$$v = r\omega$$

$$\frac{m(r\omega)}{r} = qB$$

$$\omega = \frac{qB}{m}$$

$2\pi n = \frac{qB}{m} \Rightarrow n = \frac{qB}{2\pi m}$

Frequency of revolution of electron in the orbit

$V = \frac{Bq}{2\pi m} = \frac{Be}{2\pi m_e} = \frac{6.5\times10^{-4}\times1.6\times10^{-19}}{2\times3.14\times9.1\times10^{-31}} = 18.18\times10^{6}\ Hz.$

13. a. Given, number of turns $n = 30$ radius $(r) = 8\ cm = 0.08m$

Current in the coil $I = 6A$

Magnetic field $= B = 1.0T$.

Angle made by field with the normal of the coil, $\theta = 60°$

Magnitude of torque acting on the current carrying coil due to the magnetic field

$\tau = nIAB\sin\theta$

$= 30\times6\times\pi(0.08)^2\times1\times\sin60°$

$= 30\times6\times3.14\times0.08\times0.08\times\frac{\sqrt{3}}{2}$

$= 3.133\ Nm$

b. From the formula, it is clear that the torque on the loop doesnot depend on the shape if area remains constant. So, the torque remains constant (because all other particular are unaltered).

14. For coil x

Radius of coil, $r_x = 16cm = 0.16m$

No. of turns $n_x = 20$

Current in the coil $I_x = 16A$ (anticlockwise)

For coil y

Radius of coil, $r_y = 10cm = 0.1m$

No. of turns $n_y = 25$

Current in the coil $I_y = 18A$ (clockwise).

The magnitude of the magnetic field at the centre of coil x

$B_x = \frac{\mu_0}{4\pi} \cdot \frac{2I_x \pi n_x}{r_x} = \frac{10^{-7} \times 2 \times 16 \times 3.14 \times 20}{0.16}$ T

$= 4\pi \times 10^{-4}$ T.

The direction of magnetic field due to the coil x at centre O is towards right ie east, acc. to Maxwell right hand rule.

The magnitude of the magnetic field at the centre of coil y

$B_y = \frac{\mu_0 \cdot 2\pi I_y n_y}{4\pi \cdot r_y} = \frac{10^{-7} \times 2 \times \pi \times 18 \times 25}{0.1} = 9\pi \times 10^{-4}$ T

The direction of magnetic field due to coil y at centre O is towards left ie west acc. to Maxwell left hand rule.

Here, the Magnitude of B_y is greater than B_x. So the resultant magentic field will be in the direction of B_y ie left (west).

Net magnetic field at the centre

$B = B_y - B_x = (9\pi - 4\pi) 10^{-4} = 5\pi \times 10^{-4}$

$= 1.6 \times 10^{-3}$ T

15. magnetic field $B = 100\,G = 100 \times 10^{-4}$ T $= 10^{-2}$ T

max. current $I = 15A$, $n = 1000/m$

let the product of current and number of turns in the solenoid

The magnetic magnitude of magnetic field $B = \mu_0 n I$

$nI = \frac{B}{\mu_0} = \frac{10^{-2}}{4 \times 3.14 \times 10^{-7}}$

$nI = 7961 = 8000$

Here, the product of nI is 8000 so,
current $I = 8A$.

and no. of turns $n = 1000$.

The other design is $I = 10A$ and $n = 800/m$

17.a. For outside the toroid, the magnetic field is zero, because the magnetic due to toroid is only inside it and along the length of toroid.

b. Inner radius of toroid $r_1 = 25cm = 0.25m$.
Outer radius of toroid $r_2 = 26cm = 0.26m$.
No. of turns $N = 3500$.
Current in the wire $I = 11A$.
The mean radius of the toroid $r = \frac{r_1 + r_2}{2} = \frac{2(0.25 + 0.26)}{2}$

$= 0.51$

$\therefore$ length of the toroid $= 2\pi r = 2\pi \times 0.51$
The magnetic field strength due to toroid $B = \mu_0 n I$
Where n is number of turns per unit length

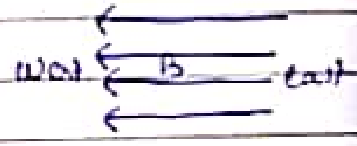
$$n = \frac{N}{l}$$

$$B = 4\pi \times 10^{-7} \times \frac{3500}{2\pi \times 0.51} \times 11 \Rightarrow 3.02 \times 10^{-2} T$$

c) The magnetic field in the empty space surrounded by the toroid is also zero because the magnetic field due to a toroid is only along it length.

18.a. The magnetic field is in constant direction from east to west. Acc. to the question a charged particle travels undeflected along a straight path with constant speed. It is only possible if the magnetic force experiencing by the charged particle is zero. The magnitude of magnetic force of a moving charged particle in a magnetic field is given by $F = qvB\sin\theta$ (where θ is the angle bet. v and B). Here $F = 0$, if and only if $\sin\theta = 0$. This indicate the angle betn its velocity and magnetic field is 0° or 180°.

Thus the charged particle moves parallel or anti-parallel to the magnetic field B.



b. Yes, the final speed be equal to its initial speed as the magnetic force acting on the charged particle only changes the direction of velocity of charged but cannot change the magnitude of velocity of charged particle.

c. As the electric field is from North to south. that means the plate in north is positive and in South is negative. Thus the electron affect towards the +ve plate that means move towards north. If we want that there is no deflection in the path of electron the magnetic force should be South direction.

By $F = -e(\vec{v} \times \vec{B})$ the direction of velocity is west to east the direction of force is towards South (by using the Fleming's left hand rule, the

Dirction of magnetic field (B) is perpendicularly Inwards to the plane of paper.

17. $V = 2kV = 2000V$, $e^- = 1.6 \times 10^{-19} C$

The electron is accelerated due to the applied potential difference which gives the kinetic energy to the ~~elec~~ electron. Let v be the velocity of e^-

$$eV = \frac{1}{2} m_e v^2$$

$$1.6 \times 10^{-19} \times 2000 = \frac{1}{2} \times 9.1 \times 10^{-31} v^2$$

$$v^2 = \frac{1.6 \times 10^{-19} \times 2000 \times 2}{9.1 \times 10^{-31}}$$

$$v = \frac{8 \times 10^7}{3} m/s = 2.7 \times 10^7 m/s.$$

a. Magnetic field $B = 0.15T$, the direction of field is transeverse to the Initial Velocity of the electron. Here the magnetic force $F = Bev$ and the direction of force is perpendicular to the magnetic field (by right hand palm rule) the electron moves on a circular path. The magnetic force provides the centri-petal force to the electron.

$$Bev = \frac{mv^2}{r}$$

Where r is the radius of circular path

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

$$= \frac{9.1 \times 10^{-31} \times 8 \times 10^7}{3 \times 0.15 \times 1.6 \times 10^{-19}}$$

$$= 10^{-3} m = 1 mm.$$

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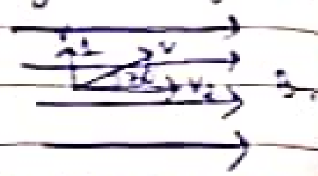
b. As the electron enters in the magnetic field at the angle 30° to the field.



Here the vertical component of velocity is v_1 and the horizontal component of velocity is v_2.

$$v_1 = V\sin 30^\circ = \frac{8\times10^{7}\times1}{3\times2} = \frac{4\times10^{7}}{3} \text{ m/s}$$

$$v_2 = V\cos 30^\circ = \frac{8\times10^{7}\times\sqrt{3}}{3\times2} = \frac{4\sqrt{3}\times10^{7}}{3} \text{ m/s}$$

The force gives the centripetal force to the e^-.

i.e. $$ev_1B = \frac{mv_1^2}{r'}$$

$$= \frac{mv_1}{eB} = \frac{9.1\times10^{-31}\times4\times10^{7}}{3\times16\times10^{-19}\times0.15}$$

$$r' = 0.5\times10^{-3}\text{ m} = 0.5\text{ mm}.$$