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# Moving Changes and Magnetism

1. Here,

$n = 100$, $r = 8cm$, $8\times10^{-2}m$

The magnitude of field B at the centre is

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi I n}{r} = \frac{10^{-7}\times2\times3.14\times0.4\times100}{8\times10^{-2}}$$

$$= 3.1\times10^{-4}\,T$$

The direction of magnetic field depends upon current.

2. Here we have to find the magnetic field at point P

$I = 35\,A$ and $r = 20cm = 0.2m$

The wire is long at it is considered as an infinite length wire

The magnetic field

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2I}{r} = \frac{10^{-7}\times2\times35}{0.2} = 3.5\times10^{-5}\,T$$

∴ Direction of magnetic field is given by Maxwells right hand rule.

6) Here, the angle between the magnetic field due to a solenoid is along the axis of solenoid and the wire is placed perpendicular to axis,

Given - $l = 3cm = 3\times10^{-2}\,m$ $\quad I = 10A \quad B = 0.2T$

The magnitude of magnetic force on ~~the~~ wire

$$F = I l B \sin 90^\circ = 10\times3\times10^{-2}\times0.27\times\sin90^\circ = 8.1\times10^{-2}\,N$$

According to right hand palm rule, the direction of magnetic ~~field~~ force is ⊥ to plane of paper in ward

7. Given :-

$I_1 = 8A$ , $I_2 = 5A$ and $r = 4cm = 0.04m$

Force per unit length on two parallel wire carrying current.

$F = \frac{\mu_0}{4\pi} \cdot \frac{2I_1 \times I_2}{r} = \frac{10^{-7} \times 2 \times 8 \times 5}{0.04} = 2 \times 10^{-4} N$

The force on A of length 10cm is $F' = F \times 0.1$

$F' = 2 \times 10^{-4} \times 0.1$

$= 2 \times 10^{-5} N$

According to flemings left hand rule, the direction of force is towards B and the nature of force is attractive.

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 = $I = 8A$

∴ The total no. of turns $N = 400 \times 5 = 2000$

and no. 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 $e^{\ominus}$ $v = 4.8 \times 10^{6} m/s$

Mass of $e^{\ominus} = 9.1 \times 10^{-31} kg$

Angle between magnetic field and $e^{\ominus}$. $\theta = 90°$

The force on the charge particle entering in the magnetic field

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

According to right hand palm rule, the direction of force ⊥ to both velocity and magnetic field.

$e(V \times B) = \frac{mv^2}{r}$ $\quad$ $ev B\sin 90^\circ = \frac{mv^2}{r}$

$r = \frac{mv}{eB \times 1} = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{6.6 \times 10^{-19} \times 6.5 \times 10^{-4}} = 4.2 \times 10^{-2}\, m$

$= 4.2\, cm$

12) Given

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

$V = 4.8 \times 10^{6}\, m/s$ $\quad$ $e = 1.6 \times 10^{-19}\, C$

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

we know that when an electron moves on a circular ~~field~~ path in uniform field, then the required centripetal force provided by magnetic force on it

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

If angular velocity of $e^{\ominus}$ is there

$V = r\omega$

$\frac{m(r\omega)}{r} = qB$ $\quad$ $\omega = \frac{qB}{M}$ $\quad$ $\Rightarrow n = \frac{qB}{2\pi m}$

Frequency of revolution of $e^{\ominus}$ in the orbit

$V = \frac{Bq}{2\pi M} = \frac{Be}{2\pi m_e} = \frac{6.5 \times 10^{-1} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$

$= 18.88 \times 10^{6}\, Hz$

Here we observe that the frequency of $e^{\ominus}$ is independant to the velocity.

14) For Coil x

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

No. of turns = $n_x$ = 20

Current in coil $I_x$ = 16A

For coil y

Radius coil $r_y$ = 10cm = 0.1m

No. of turns $n_y$ = 25

Current in coil $I_y$ = 18A

The magnitude of magnetic field at centre of coil x

$B_x = \frac{\mu_0}{4\pi} \cdot \frac{2\pi n I_x}{r_x} = \frac{10^{-3} \times 2 \times 16 \times 3.14 \times 20}{0.16}$

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

Here, magnitude of $B_y$ is greater than $B_x$. So the resultant magnetic field will be in direction of $B_y$ i.e. left (west)

Net magnetic field at centre $B = B_y - B_x$

$= (5\pi - 4\pi)10^{-4} = 5\pi \times 10^{-4}$

($\because$ $B_y$ and $B_x$ opposite to each other)

$= 1.6 \times 10^{-3}$ T (towards west)

(15) Magnetic field $B = 100G = 100 \times 10^{-4}$ T $= 10^{-2}$ T

Max. current $I$ = 15A, = 1000/m

To design the solenoid, let we find the product of current and no. of turns in the solenoid.

Magnitude of magnetic field $B = \mu_0 n I$

$nI = \frac{B}{\mu_0} = \frac{10^{-2}}{4 \times 3.14 \times 10^{-7}} \Rightarrow nI = 796100$ 8000

Here, the product $nI = 8000$

current $I = 8A$

and no. of turns $n = 1000$

The other design is $I = 10A$ and $n = 800/m$. This is the most appropriate design as the requirement

(a) Given magnetic distance is

$$B = \frac{\mu_0 NR^2}{2(x^2+R^2)^{3/2}}$$

To get the magnetic field at the centre of coil we put $x = 0$ (distance $x$ from the centre of coil at its axis).

∴ The magnetic field at centre

$$B = \frac{\mu_0 IR^2 N}{2R^3} \qquad B = \frac{\mu_0 IN}{2R}$$

The result is same as magnetic field due to current loop at centre

(b) Radius of two parallel coaxial $= R$ no of turns $= N$

Current $= I$ (same direction)

Let the mid points between the coil is point O and P be the point around the mid pt. O

suppose distance between $OP = d$ with is very less than R $(d \ll R)$

For coil A, $O_1P = \frac{R}{2} + d$

The magnetic field at point P due coil A

$$B_1 = \frac{\mu_0}{4\pi} = \frac{2\pi NIR^2}{(O_1P^2+R^2)^{3/2}}$$

$$\frac{\mu_0}{2} = \frac{NIR^2}{\{(R/2+d)^2+R^2\}^{3/2}} = \frac{\mu_0}{2} \cdot \frac{NIR^2}{(O_1P^2+R^2)^{3/2}}$$

$$= \frac{\mu_0 N I R^2}{2\cdot[R/4 + a^2 + Ra + R^2]} = \frac{\mu_0 N I R^2 \left(1 + \frac{4a}{5R}\right)^{-3/2}}{2\left(\frac{5R^2}{4}\right)^{3/2}}$$

The direction of $B_A$ is along $PO_B$ according to the maxwell right hand rule.

for the coil B, $O_B P = \frac{R}{2} - a$

Magnetic field at point P due to coil B

$$B_B = \frac{\mu_0}{4\pi} \frac{2\pi N I R^2}{(O_B P^2 + R^2)^{3/2}}$$

$$\frac{\mu_0}{2} \frac{2 N I R^2}{\left[\left(\frac{R}{2} - R\right)^2 + R^2\right]^{3/2}} = \frac{\mu_0 N I R^2 \left(1 - \frac{4a}{5a}\right)^{-3/2}}{2\left[\frac{5R^2}{4}\right]^{3/2}}$$

So, the resultant magnetic field at P due to coil A and coil B as

$B = B_A + B_B$

$$\frac{\mu_0 N I R^2}{2\left(\frac{6}{4}\right)^{2\,3/2}} = \left[\left(1 + \frac{4a}{5R}\right)^{-3/2} + \left(1 - \frac{4a}{5R}\right)^{-3/2}\right]$$

Now we binomial and neglect higher power :

$d \lll R$

$$B = \frac{\mu_0 N I R^2}{2\left(\frac{3R^2}{4}\right)^{3/2}} \left[1 - \frac{3}{2} \times \frac{4a}{5R} + 1 + \frac{3}{2} \times \frac{4a}{5R}\right]$$

$$\frac{\mu_0 N I R^2\, 4^{3/2}}{2 \times R^3 \times 5^{3/2}} \times 2$$

$$= \frac{\mu_0 N I}{2R} \left(\frac{4}{5}\right)^{3/2} \times 2 = \left(\frac{4}{5}\right)^{3/2} \frac{\mu_0 N I^2}{2R}$$

$$\frac{\mu_0 N I}{(5\sqrt{2}R}\left(\frac{4}{3}\right)^{3/2} = 0.72\frac{\mu_0 N I}{R}$$

17a) for outside the toroid, the magnetic field is zero, because the magnetic field due to ~~a~~ tonnoid is only inside it and along the length of toroid

(b) Inner radius of tonnoid = 25cm = 0.25m

outer radius of tonnoid = $r_1$ = 26cm = 0.26m

No. of turn = N = 3500

Current inside the core = I = 11A

radius of tonnoid $r = \left(\frac{r_1+r_2}{2}\right) = \frac{2}{3}(0.25+0.20)$

$= 0.51$

$\therefore$ Length of tonnoid $= 2\pi r = 2\pi \times 0.51$

$B = \mu_0 n I$

colour is no. of turn per unit length

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

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

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

18a) The initial velocity of particle is either parallel or antiparallel to magnetic field. Hence it travels along a straight path without suffering any deflection in field.

An electron travelling from west to east enters a chamber having a uniform electrostatic ~~force~~ field in the north south direction. This moving $e^{\ominus}$ can remain undeflected if the electric force acting on its equal and opposite of magnetic field. magnetic field is directed towards the south

9) Magnetic field strength ; $B = 0.15 T$

Charge on $e^{\ominus} = 1.6 \times 10^{-19} C$

mass of $e^{\ominus} = 9.1 \times 10^{-31} kg$

Potential difference $V = 20 kV = 2 \times 10^{3} V$

Thus kinetic energy of $e^{\ominus} = eV$

$\Rightarrow eV = \frac{1}{2} mv^2$

$$v = \sqrt{\frac{2eV}{m}} \quad — ①$$

where

$v$ = velocity of $e^{\ominus}$

Magnetic force on the $e^{\ominus}$ provides the required centripetal force of $e^{\ominus}$

Hence, the $e^{\ominus}$ traces a circular path of radius $r$.

Magnetic force on $e^{\ominus}$ is given by the relation

$Bev$

centripetal force $= \frac{mv^2}{r}$

$$\therefore Bev = \frac{mv^2}{r} \qquad r = \frac{mv}{Be} \quad — ②$$

from eq$^n$ ① and ②

$$r = \frac{m}{Be}\left[\frac{2eV}{m}\right]^{1/2} = \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left(\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9 \times 10^{-31}}\right)$$

$= 100.55 \times 10^{-5}$

$= 1.01 \times 10^{-3} m$

$= 1 mm$

$v_1 = v \sin\theta$

from eq$^n$ ②

$$r_1 = \frac{mv_1}{Be} = \frac{9.1 \times 10^{-31}}{0.15 \times 10^{-19} \times 1.6} \times \left[\frac{2 \times 1.6 \times 10^{-19} \times 20 \times 10^{3}}{9 \times 10^{-31}}\right] \times \sin 30$$

$= 0.5 \times 10^{-3} m = 0.5 mm$

20) Magnetic field $B = 0.75T$

Accelerating voltage ; $V = 15kV = 15 \times 10^3 V$

Electrostatic field = $\mathcal{E} = 9.0 \times 10^5 Vm^{-1}$

Mass of $e^{\ominus}$ = m

Charge of electron = e

velocity = v

K.E of $e^{\ominus}$ = eV

$\Rightarrow \frac{1}{2} mv^2 = eV$

$\therefore \frac{e}{m} = \frac{v^2}{2V}$ — ①

~~$\Rightarrow \frac{1}{2} mv^2$~~ = since the particle remains undeflected by electric and magnetic field.

$\therefore e\mathcal{E} = evB$

$v = \frac{\mathcal{E}}{B}$ — (2)

putting eqn (2) in eqn (1) we get

$\frac{e}{m} = \frac{1}{2} \frac{(\mathcal{E}/B)^2}{V} = \frac{\mathcal{E}^2}{2VB^2}$

$= \frac{(9.00 \times 10^5)^2}{2 \times 15000 \times (0.75)^2} = 4.8 \times 10^7$ C/kg

This is not unique ans.

21) Resistance of galvanometer coil ; G = 12 Ω

Current for which there is full scale deflection . $I_g = 3mA = 3 \times 10^{-3} A$

Range of voltmeter is 0. which needs to be converted to 18V

$\therefore V = 18V$

Let a resistor of Resistance R be connected in series with the galvanometer to convert it into voltmeter . This resistance is given as

$R = \frac{V}{I_g} - G = \frac{18}{3 \times 10^{-3}} - 12 = 6000 - 12 \; 5988 \; \Omega$

$\therefore$ A resistor of resistance 5988 Ω is to be connected in series with galvanometer.

28) Resistance of galvanometer coil $G = 15\,\Omega$

Current for which galvanometer shows full scale deflection

$I_g = 4\,mA = 4\times10^{-3}\,A$

Range of ammeter is 0, which needs to be converted to 6 A

$\therefore$ Current $I = 6A$

A shunt resistor of resistance S to be converted in parallel with galvanometer to convert it into an ammeter. The value of S is given as

$$S = \frac{I_g G}{I - I_g} = \frac{4\times10^{-3}\times15}{6-4\times10^{-3}}$$

$$S = \frac{6\times10^{-2}}{6-0.004} = \frac{0.06}{5.996} \approx 0.01\,\Omega = 10\,m\Omega$$

Hence, a $10\,m\Omega$ shunt resistor is to be connected in parallel with galvanometer