CHAPTER-4- MOVING CHARGES AND MAGNETISM

1 Number of turns on the circular coil $n = 100$
Radius of each turn $r = 8.0\,cm = 0.08\,m$
$I = 0.4\,A$

$|B| = \frac{\mu_0}{4\pi} \frac{2\pi n I}{r}$

where
μ_0 = permeability of free space
$= 4\pi \times 10^{-7}\ TMA^{-1}$

$|B| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2\pi \times 100 \times 0.4}{0.08}$
$= 3.14 \times 10^{-4}$ Tesla

2 $I = 35A \qquad r = 0.2\,m \qquad B = \frac{\mu_0}{4\pi} \frac{2I}{r}$

$\mu_0 = 4\pi \times 10^{-7}\ TMA^{-1}$
$B = \frac{4\pi \times 10^{-7} \times 2 \times 35}{4\pi \times 0.2}$
$= 3.5 \times 10^{-5}\ T$

6 $l = 3\,cm = 0.03\,m$
$I = 10A$
$B = 0.27\ T$
$\theta = 90^\circ$
$F = BIl \sin\theta$
$= 0.27 \times 10 \times 0.03 \sin 90^\circ$
$= 8.1 \times 10^{-2}\ N$

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7 $I_A = 8A \quad I_B = 5.0A \quad r = 0.04m \quad l = 0.1m$

$$B = \frac{\mu_0 2 I_A I_B l}{4\pi r}$$

$\mu_0 = 4\pi \times 10^{-7}\ TMA^{-1}$

$$B = \frac{4\pi \times 10^{-7} \times 2 \times 8 \times 5 \times 0.1}{4\pi \times 0.004}$$

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

8 $l = 80CM = 0.8M$

$N = 5 \times 400 = 2000$

$D = 0.0018\ M$

$I = 8.0A$

$$B = \frac{\mu_0 N I}{l}$$

$$B = \frac{4\pi \times 10^{-7} \times 2000 \times 8}{0.8} = 8\pi \times 10^{-3} = 2.512 \times 10^{-2}$$

11 $B = 6.5G = 6.5 \times 10^{-4} T$

$v = 4.8 \times 10^{6} m/s$

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

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

$\theta = 90^\circ$

$F = evB \sin\theta$

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

$F_c = F$

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

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

$$= \frac{9.1\times10^{-31}\times4.8\times10^{6}}{6.5\times10^{-4}\times1.6\times10^{-19}\times\sin 90^\circ}$$

$$\Rightarrow 4.2\times10^{-2}\,m = 4.2\,cm$$

12 a $n = 30$

$r = 0.08m$

Area of coil $= \pi r^2 = \pi(0.08)^2 = 0.0201\,m^2$

$I = 6.0A$

$B = 1T$

$\theta = 60^\circ$

$\tau = nIBA\sin\theta$

$= 30\times6\times1\times0.0201\times\sin60^\circ$

$= 3.133\,Nm$

b It can be inferred from relation that the magnitude of the applied ~~force~~ torque is not dependant on the shape of the coil. It depends on area of coil. Hence the answer would not change if the circular coil in the above case is replaced by a planar coil ~~by~~ of some irregular shape that encloses the same area.

14 $r_1 = 0.16m$ $r_2 = 10cm$ $n_1 = 20$ $n_2 = 25$ $I_1 = 16A$

$I_2 = 18A$

$$B_1 = \frac{\mu_0 n_1 I_1}{2r_1} = \frac{4\pi\times10^{-7}\times20\times16}{2\times0.16} = 4\pi\times10^{-4}\,T$$

(towards east)

$$B_2 = \frac{\mu_0 n_2 I_2}{2r_2} = \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.10}$$

$\Rightarrow 9\pi \times 10^{-4}$ T (towards west)

$B = B_2 - B_1$
$= 9\pi \times 10^{-4} - 4\pi \times 10^{-4}$
$= 5\pi \times 10^{-4}$ T
$= 1.57 \times 10^{-3}$ T (towards West)

15 $B = 100\ G = 100 \times 10^{-4}$ T
$n = 1000$ turns m^{-1}
$I = 15$ A
$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$B = \mu_0 n I$

$$\frac{100 \times 10^{-4}}{4\pi \times 10^{-7}} = 7957.47$$
$$\simeq 8000\ A/m$$

If the length of the coil is taken as 50 cm radius 4 cm turns 400 and I = 10A then these values are not unique.

17 $r_1 = 0.25$ M $r_2 = 0.26$ M N = 3500
$I = 11$ A

a) Magnetic field outside a toroid is zero. It is non-zero only inside the core of a toroid.

b $B = \frac{\mu_0 N I}{l}$

$l = 2\pi \left[\frac{x_1 + x_2}{2} \right]$

$= 2\pi \, [0.25 + 0.26]$

$= 0.51\pi$

$\therefore B = \frac{4\pi \times 10^{-7} \times 3500 \times 11}{0.51\pi}$

$= 3.0 \times 10^{-2} \, T$

c It is zero

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

b Yes it will be equal because magnetic force can change the direction of velocity but not its magnitude.

c An electron travelling from west to east enter a chamber having a uniform electrostatic field in the N - S direction. The moving electron can remain undeflected if the electric force acting on it is equal and opposite of B. Magnetic force is directed towards the south. According to fleming's left hand rule, magnetic field should be applied in a vertically downward direction.

19 $B = 0.15\,T$

$e = 1.6 \times 10^{-19}\,C$

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

$V = 2.0\,kV = 2 \times 10^{3}\,V$

eV

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

$v = \sqrt{\frac{2eV}{m}}$

a Magnetic force on the electron provides the required centripetal force of the electron. Hence, the electron traces a circular path of radius r.
Magnetic force on the electron is given by the relation

Bev

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

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

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

$r = \frac{m}{Be}\left[\frac{2eV}{m}\right]^{\frac{1}{2}}$

$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left(\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9.1 \times 10^{-31}}\right)^{\frac{1}{2}}$

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

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

$= 1\,mm$

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b $v_\perp = v\sin\theta$

$$r_\perp = \frac{mv_\perp}{Be} = \frac{mv\sin\theta}{Be} = \frac{9.1\times10^{-31}}{0.15\times1.6\times10^{-19}} \times \left[\frac{2\times1.6\times10^{-19}\times10^{3}\times2\times10^{3}}{9\times10^{-31}}\right] \times \sin 30^\circ$$

$= 0.5\times10^{-3}\,m$

$= 0.5\,mm$

20 $B = 0.75\,T$

$V = 15\,kV = 15\times10^{3}\,V$

$E = 9\times10^{5}\,Vm^{-1}$

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

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

Since the particle remains undeflected by electric and magnetic fields, we can infer that the electric field is ~~blancing~~ balancing the magnetic field.

$\therefore eE = evB$

$v = \frac{E}{B}$

$$\Rightarrow \frac{e}{m} = \frac{1}{2}\frac{\left(\frac{E}{B}\right)^2}{V} = \frac{E^2}{2VB^2}$$

$$= \frac{(9.0\times10^5)^2}{2\times15000\times(0.75)^2} = 4.8\times10^{7}\,C/kg$$

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Q7 $G = 12\,\Omega$

$I = 3\,mA = 3 \times 10^{-3}\,A$

$V = 18\,V$

$$R = \frac{V}{I_g} - G$$

$$= \frac{18}{3 \times 10^{-3}} - 12 = 6000 - 12 = 5988\,\Omega$$

Hence a resistor $5988\,\Omega$ is to be connected in the series with galvanometer.

Q8 $G = 15\,\Omega$

$I_g = 4\,mA = 4 \times 10^{-3}\,A$

$I = 6\,A$

$$S = \frac{I_g G}{I - I_g} = \frac{4 \times 10^{-3} \times 15}{6 - 4 \times 10^{-3}}$$

$$S = \frac{6 \times 10^{-2}}{6 - 0.004} = \frac{0.06}{5.996}$$

$$= 0.01\,\Omega = 10\,m\Omega$$

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