MOVING CHARGES AND MAGNETISM

1. The magnitude of the magnetic field at the centre of a circular coil of radius r carrying current I is given by,

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

For 100 turns, the magnitude of the magnetic field will be,

$$|B| = 100 \times \frac{\mu_0 I}{2r}$$

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

$$= 3.14 \times 10^{-4}\ T$$

2. $I = 35A$

$r = 20cm = 0.2m$

magnitude of the magnetic field at this point =

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

μ_0 = Permeability of free space $= 4\pi \times 10^{-7}\ Tm/A$

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

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(6) $l = 3cm = 0.03m$
$I = 10A$
$B = 0.27T$
~~θ = 90°~~ Angle between the current and magnetic field, $\theta = 90°$

$F = BIl\sin\theta$
$= 0.27 \times 10 \times 0.03 \sin 90°$
$= 8.1 \times 10^{-2} N$
$= 8.1 \times 10^{-2} N$

(7) Current flowing from wire A, $I_A = 8.0A$
" " " wire B $I_B = 5.0A$
Distance between the two wires, $r = 4.0cm = 0.04m$
Length of a section of wire A, $l = 10cm = 0.1m$
Force exerted on length l due to the magnetic field is given as:

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

μ_0 = Permeability of free space $= 4\pi \times 10^{-7} TmA^{-1}$

$$B = \frac{4\pi \times 10^{-7} \times 2 \times 8 \times 5 \times 0.1}{4\pi \times 0.04}$$
$$= 2 \times 10^{-5} N$$

(11) Magnetic field strength, $B = 6.5G = 6.5 \times 10^{-4} T$
Speed of the electron, $v = 4.8 \times 10^6 m/s$
Charge on the electron $e = 1.6 \times 10^{-19} C$
Mass of the electron, $m_e = 9.1 \times 10^{-31} Kg$
Angle between the shot electron and magnetic field, $\theta = 90°$

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$F = evB\sin\theta$

The force provides centripetal force to the moving electron. Hence, the electron starts moving in a circular path of radius r.

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

In equilibrium, the centripetal force exerted on the electron is equal to the magnetic force

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

$$r = \frac{mv}{Be\sin\theta}$$
$$= \frac{9.1 \times 10^{-31} \times 4.8 \times 10^6}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90}$$

$$= 4.2 \times 10^{-2} m = 4.2cm$$

(12) $B = 6.5 \times 10^{-4} T$
$e = 1.6 \times 10^{-19} C$
$m_e = 9.1 \times 10^{-31}$
$v = 4.8 \times 10^6 m/s$
$r = 4.2cm = 0.042m$
Frequency of revolution of the electron $= \nu$
Angular frequency of the electron $= \omega = 2\pi\nu$
A/Q,
$$evB = \frac{mv^2}{r}$$

$$eB = \frac{m}{r}(r\omega) = \frac{m}{r}(r2\pi\nu)$$

$$\nu = \frac{Be}{2\pi m}$$

on ~~substitut~~ substituting the known values in the expression, we get the frequency as

$$\nu = \frac{6.5 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$$

$$= 18.2 \times 10^{6}\ Hz$$
$$= 18\ MHz$$

(13) $n = 30$

$r = 8.0cm = 0.08m$

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

$I = 6.0A$

$B = \cancel{0.1}\ 1T$

$\theta = 60^\circ$

The coil experiences a torque in the magnetic field. Hence it turns. The counter torque applied to prevent the coil from turning is given by the relation.

$$\tau = nIBA\sin\theta \quad —①$$
$$= 30 \times 6 \times 1 \times 0.0201 \times \sin 60^\circ$$
$$= 3.133\ Nm$$

(14) Radius of coil X, $r_1 = 16cm = 0.16m$

Radius of coil Y, $r_2 = 10cm = 0.1m$

Number of turns of on coil X, $n_1 = 20$

Number of turns of on coil Y, $n_2 = 25$

Current in coil X, $I_1 = 16A$

Current in coil Y, $I_2 = 18A$

Magnetic field due to coil X at their centre is given by the relation

$$B_1 = \frac{\mu_0 n_1 I_1}{2r_1}$$

where,

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

$$\therefore B_1 = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0.16}$$

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

$$B_2 = \frac{\mu_0 n_2 I_2}{2r_2}$$
$$= \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.10} = 9\pi \times 10^{-4} T$$

Hence, net magnetic field can be obtained as:

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

(15) Magnetic field strength $B = 100G = 100 \times 10^{-4} T$
Number of turns per unit length, $n = 1000$ turns m^{-1}
$I = 15 A$
$\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$
Magnetic field is given by the relation
$B = \mu_0 n I$

$\therefore nI = \frac{B}{\mu_0}$

$= \frac{100 \times 10^{-4}}{4\pi - 10^{-7}} = 7957.74$

(17) $r_1 = 25cm = 0.25m$
$r_2 = 26cm = 0.26m$
$N = 3500$
$I = 11A$

$B = \frac{\mu_0 NI}{l}$

where,
μ_0 = Permeability of free space $= 4\pi \times 10^{-7} TmA^{-1}$
l = length of toroid.

$= 2\pi \left[\frac{r_1 + r_2}{2}\right]$

$= \pi (0.25 + 0.26)$
$= 0.51\pi$

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

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

(18) (a) The initial velocity of the particle is either parallel or anti parallel to the magnetic field. Hence, it travels along as straight path without suffering any deflection in the field.
(b) Yes, the final speed of the charged particle will be equal to its initial speed. This is ~~bec~~ because magnetic force can change the direction of velocity, but not its magnitude
(c) An electron travelling from West to East enters a chamber having a uniform ~~electo~~ electrostatic field in the North Sout direction.

(19) (a) Magnetic force on the electron provides the required centripital force of the electron. Hence, the electron traces a circular path of radius r.

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

$r = \frac{mv}{Be}$ — (2)

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

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

$= 100.55 \times 10^{-5}$
$= 1.01 \times 10^{-3} m = 1m$

(b) when the field makes an angle θ of 30° with initial velocity, the initial velocity will be,

$$v_1 = v \sin\theta$$

$$a_1 = \frac{m v_1}{Be} = \frac{m v \sin\theta}{Be}$$

$$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left[\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9 \times 10^{-31}}\right]^{\frac{1}{2}} \sin 30°$$

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

$$= 0.5\ mm$$

~~(24) (a) Magnetic fo~~

(24) (a) Torque, $\vec{\tau} = I\vec{A} \times \vec{B}$

$$\therefore \tau = 12 \times (50 \times 10^{-4})\ \hat{i} \times 0.3\ \hat{k}$$

$$= -1.8 \times 10^{-2}\ \hat{j}\ Nm$$

(b) This case is similar to case (a). Hence, the answer is the same as (a)

(c) Torque $\tau = I\vec{A} \times \vec{B}$

$$\tau = -12 \times (50 \times 10^{-4})\ \hat{j} \times 0.3\ \hat{k}$$

$$= -1.8 \times 10^{-2}\ \hat{i}\ Nm$$

(d) Magnitude of torque is given as:

$$|\tau| = IAB$$

$$= 12 \times 50 \times 10^{-4} \times 0.3$$

$$= 1.8 \times 10^{-2}\ Nm$$

(c) Torque $\tau = I\vec{A} \times \vec{B}$

$$= (50 \times 10^{-4} \times 12)\ \hat{k} \times 0.3\ \hat{k}$$

$$= 0$$

(27) $G = 12\ \Omega$

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

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

$\therefore V = 18\ V$

The resistance is given as:

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

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

(28) $G = 15\ \Omega$

Current for which the ~~galva~~ galvanometer shows full scale deflection,

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

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

$I = 6\ A$

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

$$S = \frac{I_g G}{I - I_g}$$

$$= \frac{4 \times 10^{-3} \times 15}{6 - 4 \times 10^{-3}}$$

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

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