24 Jul

Ncert Exercise :- Chapter-4

1. Given $N = 100$, $r = 8\text{ cm} = 0.08\text{ m}$, $I = 0.40\text{ A}$

$\therefore B = \frac{\mu_0 N I}{2r} = \frac{4\pi \times 10^{-7} \times 100 \times 0.40}{2 \times 0.08}$

$= \pi \times 10^{-4} = 3.1 \times 10^{-4}\text{ T}$

2. $I = 35\text{ A}$, $r = 20\text{ cm} = 0.20\text{ m}$

$\mu_0 = 4\pi \times 10^{-7}\text{ T m A}^{-1}$

$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 35}{2\pi \times 0.20} = 3.5 \times 10^{-5}\text{ T}$

6. Given $l = 3.0\text{ cm} = 0.03\text{ m}$, $I = 10\text{A}$.

$\theta = 90^\circ$, $B = 0.27\text{ T}$

$F = IBl \sin\theta = 10 \times 0.03 \times 0.27 \times \sin 90^\circ$

$= 8.1 \times 10^{-2}\text{ N}$

The direction of the force is given by Fleming's left hand rule.

7. Force per unit length of each wire is

$f = \frac{\mu_0 I_1 I_2}{2\pi r} = \frac{4\pi \times 10^{-7} \times 8 \times 5}{2\pi \times 4 \times 10^{-2}} = 2 \times 10^{-4}\text{ N m}^{-1}$

Force on 10cm section of wire A is

$F = fl = 2 \times 10^{-4} \times 10 \times 10^{-2} = 2 \times 10^{-5}\text{ N}$.

8. Number of turns per unit length of Solenoid = layer × No. of layer

$= \frac{400 \times 5}{0.80} = 2500\text{ m}^{-1}$

Magnetic field inside the solenoid is

$B = \mu_0 n I = 4\pi \times 10^{-7} \times 2500 \times 8 = 8\pi \times 10^{-3}\text{ T}$

$= 2.5 \times 10^{-2}\text{ T}$

11. The perpendicular magnetic field exerts a force on the electron perpendicular to its path. This force continuously deflects the electron from its path and makes it move along a circular path.

$\therefore$ Magnetic force on the electron = centripetal force

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

$$r = \frac{m_e v}{eB}$$

Now $B = 6.5\,G = 6.5 \times 10^{-4}\,T$, $v = 4.8 \times 10^{6}\,ms^{-1}$

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

12. frequency of revolution of the electron in its circular orbit,

$$f = \frac{eB}{2\pi m} = \frac{1.6 \times 10^{-19} \times 6.5 \times 10^{-4}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$$

$$= 18.18 \times 10^{6}\,Hz = 18\,MHz$$

No, the frequency f does not depends on the speed v of the electron.

13. a) $N = 30$, $r = 8.0\,cm = 0.08\,m$, $I = 6.0\,A$, $B = 1\,T$, $\theta = 60^\circ$

Magnitude of counter torque
= Magnitude of deflection torque
$= NIBA \sin\theta$
$= 30 \times 6 \times 1 \times (3.14 \times 0.08 \times 0.08) \sin 60^\circ$
$= 30 \times 6 \times 3.14 \times 64 \times 10^{-4} \times 0.866 = 3.1\,Nm$

b) No, the answer would not change because the above formula for the torque is true for a planar loop of any shape.

15 Here $B = 100 \; G = 10^{-3} T$, $I = 15A$, $n = 1000$ turns m^{-1}

magnetic field inside a solenoid,

$B = \mu_0 n I$

$\therefore nI = \frac{B}{\mu_0} = \frac{10^{-2}}{4\pi \times 10^{-7}} = 7955 \simeq 8000$

we may take $I = 10A$, then $n = 800$

The solenoid may have length 50 cm and area of cross-section $5 \times 10^{-2} m^2$ so as to avoid edge effect, etc.

17 Here, $I = 11A$, total number of turns = 3500

Means radius of toroid,

$r = \frac{25 + 26}{2} = 25.5$ cm $= 25.5 \times 10^{-2}$ m

Total length (circumference) of the toroid = $2\pi r$

$= 2\pi \times 25.5 \times 10^{-2} = 51.0 \times 10^{-2} \pi$ m

$\therefore$ Number of turns per unit length,

$n = \frac{3500}{51.0 \times 10^{-2} \pi}$

(a) The field outside the toroid is zero.

(b) The field inside the core of the toroid,

$B = \mu_0 n I = 4\pi \times 10^{-7} \times \frac{3500}{51.0 \times 10^{-2} \pi} \times 11$

$= 3.02 \times 10^{-2} T$

(c) The field in the empty space surrounded by the toroid is also zero.

18 (a) The force on a charged particles moving in a magnetic field is given by

$$f = qvB \sin\theta$$

The force on a charged particles will be zero or the particle will remain undeflected if

$\sin\theta = 0$ or $\theta = 0°, 180°$

initial velocity $\vec{v}$ is either parallel or antiparallel to $\vec{B}$.

(b) Yes, a magnetic field exerts force on a charged particle in a direction perpendicular to its direction of motion and hence does no work on it. So the charged particle will have its final speed equal to its initial speed.

c) The electron travelling west to east experience a force towards north due to the electrostatic field. It will remain undeflected if it experences an equal force towards south due to the magnetic field. According to Fleming's left hand rule, the magnetic field must act in the vertically downward direction.

19 $V = 2.0\,kV = 2\times10^{3}\,V$, $B = 0.15\,T$

$e = 1.6\times10^{-19}\,C$, $m = 9.1\times10^{-31}\,kg$

Potential difference V imparts kinetic energy to the electron given by

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

or, velocity gained by electron.

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2\times1.6\times10^{-19}\times2\times10^{3}}{9.1\times10^{-31}}}\ ms^{-1}$$

$$= 2.65\times10^{7}\ ms^{-1}$$

i) When field $\vec{B}$ is transverse to the initial velocity $\vec{v}$.

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

$$\therefore r = \frac{mv}{eB} = \frac{9.1 \times 10^{-31} \times 2.65 \times 10^7}{1.6 \times 10^{-19} \times 0.15} \text{ m}$$

$$= 10^{-3} \text{ m} = 1 \text{ mm}$$

Thus the electron follows a circular trajectory of radius 1 mm normal to the field B.

ii) When field $\vec{B}$ makes an angle of 30° to the initial velocity $\vec{v}$,

$$V_\perp = v \sin 30^\circ = 2.65 \times 10^7 \times \frac{1}{2} = 1.33 \times 10^7 \text{ ms}^{-1}$$

$$V_\parallel = V \cos 30^\circ = 2.65 \times 10^7 \times 0.866 = 2.3 \times 10^7 \text{ ms}^{-1}$$

The radius of the helical path is given by

$$r = \frac{mv_\perp}{eB} = \frac{mv \sin 90^\circ}{eB} = \frac{9.1 \times 10^{-31} \times 1.33 \times 10^7}{1.6 \times 10^{-19} \times 0.15}$$

$$= 50.4 \times 10^{-5} \text{ m} = 0.50 \text{ mm}.$$

20 $B = 0.75\text{ T}$, $E = 9.0 \times 10^5 \text{ V m}^{-1}$,

$V = 15 \text{ kV} = 15 \times 10^3 \text{ V}$

For undeflected beam, velocity of charged particles must be

$$v = \frac{E}{B} = \frac{9.0 \times 10^5}{0.75} \text{ ms}^{-1} = 12 \times 10^5 \text{ ms}^{-1}$$

But the kinetic energy of the charged particles is given by

$$\frac{1}{2}mv^2 = qV$$

$$\therefore \frac{q}{m} = \frac{1}{2} \cdot \frac{v^2}{V} = \frac{1}{2} \times \frac{(12 \times 10^5)^2}{15 \times 10^3} \ C\ kg^{-1}$$

$$= 4.8 \times 10^7 \ C kg^{-1}$$

Now For deutrons,

$$\frac{q}{m} = \frac{1.6 \times 10^{-19}}{2 \times 1.67 \times 10^{-27}} = 4.8 \times 10^7 \ C\ kg^{-1}$$

Which means that the particles may be deutrons each of which contains one proton and one neutron. The answer is not unique because we have determined only the ratio of charge to mass. Other possible answer are He^{2+} & Li^{3+}, etc.

24 Here $B = 3000\ G = 3000 \times 10^{-4} = 0.3\ T$

$A = 10 \times 5 = 50 cm^2 = 50 \times 10^{-4} m^2$, $I = 12A$

Magnetic moment,

$$m = IA = 12 \times 50 \times 10^{-4} = 0.06 Am^2$$

We apply right hand rule to various current loops to decide the direction of $\vec{m}$.

a) Here $\vec{m} = 0.06\hat{i}\ Am^2$, $B = 0.3\hat{k}\ T$

$$\therefore \vec{\tau} = \vec{m} \times \vec{B}$$

$$= 0.06\hat{i} \times 0.3\hat{k} = -1.8 \times 10^{-3}\hat{j}\ Nm$$

Thus a torque of 1.8×10^{-2} Nm acts along -ve Y-axis

b) Here $\vec{m} = 0.06\hat{i}$ Am^2, $\vec{B} = 0.3\hat{k}$ T

Clearly, $\vec{m}$ & $\vec{B}$ are same as in case (a).
In this case also, a torque of 1.8×10^{-2} Nm acts along -ve Y-axis.

c) Here $\vec{m} = -0.06\hat{j}$ Am^2, $\vec{B} = 0.3\hat{k}$ T

$$\vec{\tau} = \vec{m} \times \vec{B}$$
$$= -0.06\hat{i} \times 0.3\hat{k} = -1.8 \times 10^{-2}\,\hat{i}\ Nm$$

Thus a torque of 1.8×10^{-2} Nm acts along -ve X-axis

d) This case is similar to case (c). But here the direction of the torque is 60° anticlockwise negative x-direction i.e. 240° with +ve x-direction.

e) Here $\vec{m} = 0.06\hat{k}$ Am^2, $\vec{B} = 0.3\hat{k}$ T

$$\therefore \vec{\tau} = \vec{m} \times \vec{B} = 0.06\hat{k} \times 0.3\hat{k} = 0$$

It corresponds to stable equilibrium, because here $\vec{m}$ is parallel to $\vec{B}$.

f) Here $\vec{m} = -0.06\hat{k}$ Am^2, $\vec{B} = 0.3\hat{k}$ T

$$\therefore \vec{\tau} = \vec{m} \times \vec{B} = -0.06\hat{k} \times 0.3\hat{k} = 0$$

The net force on the loop is zero in each case.
It corresponds to unstable equilibrium, because here $\vec{m}$ is antiparallel to $\vec{B}$.

27 Here $R_g = 12\Omega$, $I_g = 3mA = 3\times10^{-3} A$, $V = 18V$

$$R = \frac{V}{I} - R_g = \frac{18}{3\times10^{-3}} - 12$$

$$= 6000 - 12 = 5988\ \Omega$$

By connecting a resistance of 5988 in series with the given galvanometer, we get a voltmeter of range 0 to 18 V.

28 Here $R_g = 15\Omega$, $I_g = 4mA = 0.004 A$, $I = 6A$

$$R_s = \frac{I_g}{I - I_g} \times R_g = \frac{0.004}{6 - 0.004} \times 15$$

$$= 0.010\ \Omega = 10 m\Omega$$

By connecting a shunt of resistance $10 m\Omega$ across the given galvanometer, we get an ammeter of range 0 to 6A.