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Homework Physics
Ch-4 Moving charges and Magnetism

4.1

The number of turns on the coil (n) is 100
The radius of each turns (r) is 8 cm or 0.08 m
The magnitude of the current flowing in the coil (I) is 0.4 A
The magnitude of the magnetic field at the centre of the coil can be obtained by the following relation:

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

where μ_0 is the permeability of free space
$= 4\pi \times 10^{-7}\ Tm/A$.

hence,

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

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

The magnitude of the magnetic field is $3.14 \times 10^{-4}\ T$

2. The magnitude of the current flowing in the wire (I) is 35 A.
The distance of the point ~~the magnitude of the~~ from the wire (r) is 20cm or 0.2m
At this point, the magnitude of the magnitude field is given by the relation:—

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

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

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Substituting the values in the equation, we get

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

$$= 3.5 \times 10^{-5}\ T$$

Hence, the magnitude of the magnetic field at a point 20cm from the wire is 3.5×10^{-5} T

6.

In this problem,
the length of the wire (l) is 3cm or 0.03 m
the magnitude of the current flowing in the wire (I) is 10 A.
the strength of the ~~magnitude~~ magnetic field is ~~or...~~ is 0.27 T
The angle between the current and magnetic field is $\theta = 90°$
The magnetic force exerted on the wire is calculated as follows:-

$F = BIl \sin\theta$

Substituting the values in the above equat

$= 0.27 \times 10 \times 0.03 \times \sin 90°$

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

∴ The direction of the force can be obtained from Fleming's left-hand rule.

7. The magnitude of the current flowing in the wire A (I_A) is 8 A.
The magnitude of the current flowing in wire B (I_B) is 5 A.
~~The length o~~
The distance between the two wires (r) is 4cm or 0.

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The length of the section of wire A $(l) = 10\,cm = 0.1\,m$
The force ~~extended on~~ exerted on the length l due to the magnetic field is calculated as follows:

$$f = \frac{\mu_0 I_A I_B L}{2\pi r}$$

where,
~~μ_0~~ μ_0 = Permeability of free space $= 4\pi \times 10^{-7}\, Tm A^{-1}$
Substituting the values, we get

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

The magnitude of force is $2 \times 10^{-5} N$. This is ~~an~~ attractive force normal to A towards B because the direction of the currents in the wires is the same.

8

Solenoids length $(L) = 80\,cm = 0.8\,m$
Five layers of windings of 400 turn each on the solenoid.

∴ Total number ~~on~~ of turns on the solenoid, $N = 5 \times 400 = 2000$

Solenoid Diameter $(D) = 1.8\,cm = 0.018\,m$
The current carried by the solenoid $(I) = 8.0\,A$
The relation that gives the magnitude of the magnetic fields inside the solenoid near its centre is given below :-

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

Where,
μ_0 = Permeability of free space $= 4\pi \times 10^{-7}\, Tm A^{-1}$

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

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

Hence the magnitude of B inside the solenoid near its centre is 2.5×10^{-2} T.

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Magnetic field strength, $B = 6.5$ G $= 6.5 \times 10^{-4}$ 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, $\theta = 90°$

$F = evB \sin\theta$

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

Hence, centripetal force exerted on the electron,

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

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

$F_c = F$

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

$$\Rightarrow \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90°}$$

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

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Magnetic field strength, $B = 6.5 \times 10^{-4}T$
Charge of the electron, $e = 1.6 \times 10^{-19}C$
Mass of the electron, $m_e = 9.1 \times 10^{-31} kg$
Velocity of the electron $= 4.8 \times 10^{6} m/s$
Radius of the orbit, $r = 4.2cm = 0.042m$
Frequency of revolution of the electron $= \nu$
Angular frequency of the electron $\omega = 2\pi\nu$
Velocity of the electron is related to the angular frequency as:-
$v = r\omega$

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

$$eB = \frac{m}{r}(r\omega) = \frac{m}{r}(4^2\pi\nu)$$

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

This expression for frequency is independent of the speed of the electron.
On substituting the known values in this expression, we get the frequency as:-

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

$$= 1.82 \times 10^{6} Hz = 18 MHz$$

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(a) No. of turns on the circular coil $n = 30$
Radius of the coil, $r = 8.0$ cm $= 0.08$ m
Area of the coil $= \pi r^2 = \pi (0.08)^2 = 0.0201\, m^2$
Current flowing in the coil, $I = 6.0$ A
Magnetic field strength $B = 1$ T

Angle between the field lines and normal with the coil surface, $\theta = 90°$

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

$T = nIBA \sin\theta$ ——— (1)
$= 30 \times 6 \times 1 \times 0.0201 \times \sin 60°$
$= 3.133$ Nm

(B) It can be inferred from relation (1) that the magnitude of the applied torque is not dependent on the shape of the coil. It depends on the area of the coil. Hence, the answer would not change if the circular coil in the above case is replaced by a planar coil of some irregular shape that encloses the same area

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Radius of coil X, r_1 = 16 cm = 0·16 m
Radius of coil Y, r_2 = 10 cm = 0·1 m
No. of turns of on coil X, n_1 = 20
No. of turns of on coil Y, n_2 = 25
Current in coil X, I_1 = 16A
current in coil Y, I_2 = 18 A
Magnetic field due to coil X at their centre is given by the relation

$$B_1 = \frac{\mu_0 n_1 I_1}{2r_2}$$

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

$$B_1 = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0{\cdot}16} = 4\pi \times 10^{-4}\, T \text{ (towards east)}$$

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

$$B_2 = \frac{\mu_0 n_2 I_2}{2r_2}$$

$$B_1 = \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0{\cdot}10}$$

$$= 9\pi \times 10^{-4}\, T \text{ (toward east)}$$

Hence, net magnetic field can be obtained as:-

$$B = B_2 - B_1$$

$$= 9\pi \times 10^{-4} - 4\pi \times 10^{-4}$$

$$= 5\pi \times 10^{-4}\, T$$

$$= 1{\cdot}57 \times 10^{-3}\, T \text{ (toward west)}$$

15) magnetic field strength, $B = 100G = 100 \times 10^{-4} T$
No. of turns per unit length $n = 1000$ turns m^{-1}
current flowing in the coil, $I = 15A$
Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$
Magnetic field is given the relation,

$B = \mu_0 n I$

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

$\frac{100 \times 10^{-4}}{4\pi \times 10^{-7}} = 7657.74$

$= 8000 A/m$

If the length of the coil is taken as 50cm, radius 4cm, number of turns 400, and current 10A, then these values are not unique for the given purpose.

18 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, the final speed of the charged particle ~~will~~ will be equal to its initial speed. This is because magnetic force can change direction of velocity, but not its magnitude.

c An electron travelling from west to east enters a chamber having a uniform electrostatic field in the north-south direction.
Magnetic force is directed towards the south.
According to Fleming's left hand rule, magnetic

field should be applied in a vertically downward direction.

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Magnetic field strength, $B = 0.15\,T$
charge on the electron $= 1.6 \times 10^{-19}\,C$
Mass of the electron $m = 9.1 \times 10^{-31}\,kg$
Potential difference, $V = 2.0\,kV = 2 \times 10^{3}\,V$
Thus K.E of the electron $= eV$

$$\Rightarrow eV = \frac{1}{2} m v^2$$

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

where :-

v = Velocity of the electron.

(a) Magnetic force on the electron provide the required centripetal force of the e^-. Hence, the electron traces a circular path of r.

magnetic force on the e^- is given by the relation BeV

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

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

$$r = \frac{mv}{Be} \quad \text{——— (2)}$$

From eq (1) and (2) we get

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

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

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

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

$= 1$ mm

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

$v_1 = v \sin\theta$

$$r_1 = \frac{mv_1}{Be}$$

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

$$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9 \times 10^{-31}}} \times \sin 30°$$

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

20.

Magnetic field, $B = 0.75$ T

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

Electrostatic field $E = 9 \times 10^5$ Vm^{-1}

Mass of the electron $= m$

Charge of the electron $= e$

velocity of the electron $= v$

K.E of the electron $= eV$

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

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

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

$\therefore eE = evB$

$v = \frac{E}{B}$ ——— (2)

Putting eq (2) in equation (1) we get

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

$= \frac{(9.0 \times 10^5)^2}{2 \times 15000 \times (0.75)^2} = 4.8 \times 10^7 \, C/kg$

The value of specific charge e/m is equal to the value of deuteron or deuterium ion.

24 magnetic field strength

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

length of the loop, $l = 10 cm$

width of the loop, $b = 5 cm$

Area of the loop :-

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

current in the loop $I = 12 A$

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

From the given figure, it can be observed the A is normal to the y-z plane and B is directed along the z axis

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

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

The force on the loop is 0 because the angle between A and B is zero.

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(b) The case is same as case A. Hence, the answer is the same as (a).

c) Torque $= \tau = I\vec{A} \times \vec{B}$
From the given figure, it can be observed that A is normal to the x-z plane and B is directed along the z-axis.
$\tau = 12 \times (50 \times 10^{-4})\hat{j} \times 0.3\hat{k}$
$= 1.8 \times 10^{-2}\hat{i}$ ~~Nm~~ Nm

The ~~larg~~ torque is 1.8×10^{-2} Nm along the negative x direction and the ~~for~~ force is zero.

(d)
magnitude of torque is given as :-
$|\tau| = IAB$
$= 12 \times 50 \times 10^{-4} \times 0.3$
$= 1.8 \times 10^{-2}$ Nm
Torque is 1.8×10^{-2} Nm at an angle of $240°$ with positive x direction. The force is zero.

(e) Torque ~~for~~ $\tau = I\vec{A} \times \vec{B}$
$= (50 \times 10^{-4} \times 12)\hat{k} \times 0.3\hat{k}$
$= 0$
Hence torque is zero.

(f) Torque $= I\vec{A} \times \vec{B}$
$= (50 \times 10^{-4} \times 12)\hat{k} \times 0.3\hat{k}$
$= 0$
Hence the torque is zero. The force is also zero.

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Resistance of the galvanometer coil, $G = 12\,\Omega$

Current for which there is full scale deflection.

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

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

$\therefore V = 18V$

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

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

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

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

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

Current for which the G shows full scale deflection.

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

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

current $I = 6A$.

A shunt resistor of ~~r~~ S is to be connected to parallel with the galvanometer to convert it into an ammeter.