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Ch-4 Moving charges and magnetism

(1) Ans no. of turns on the coil, $n = 100$
radius, $r = 8 cm = 0.08 m$
current flowing in the coil, $I = 0.4 A$

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

Where,
μ_0 = permeability of free space.
$= 4\pi \times 10^{-7} T m A^{-1}$

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

∴ Magnitude of mag. field is $3.14 \times 10^{-4} T$.

(2) Ans Current in wire, $I = 50 A$
A point is 2.5m away from the East of wire.

∴ mag. of the distance of the point from wire, $r = 2.5 m$

mag. of magnetic field $= B = \frac{\mu_0 2I}{4\pi r}$

$$B = \frac{4\pi \times 10^{-7} \times 2 \times 50}{4\pi \times 2.5} = 4 \times 10^{-6} T$$

The dirn. of the current in the wire is vertically downward.
∴ dirn. of magnetic field is vertically upward

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(6) Ans length of the wire, $l = 3cm = 0.03m$
Current flowing in wire, $I = 10A$
Magnetic field, $B = 0.27T$
Angle b/w current and magnetic field, $\theta = 90°$.

$F = BIl\sin\theta$
$= 0.27 \times 10 \times 0.03 \sin 90°$
$= 8.1 \times 10^{-2} N$.
$\therefore$ Magnetic force on wire is $8.1 \times 10^{-2} N$.

(7) Ans Current flowing in wire A, $I_A = 8A$
Current " " " B, $I_B = 5A$

Dist. b/w two wire, $r = 4cm$, $r = 0.04m$
length of sec. of wire A, $l = 10cm = 0.1m$
Force exerted

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

where,

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

$= 2 \times 10^{-5} N$
$\therefore$ Magnitude of force is $2 \times 10^{-5} N$.

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(i) Ans Length of solenoid, $l = 80\ cm$, $0.8m$
There are five layers, 400 turns on each solenoid
∴ Total no of turns on solenoid,
$N = 5 \times 400 = 2000$
Diameter of solenoid, $D = 1.8\ cm$, $0.018m$
Current carried by solenoid, $I = 8A$

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

where,

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

$$= 8\pi \times 10^{-3} = 2.512 \times 10^{-2}\ T$$

∴ The magnitude of field is $2.512 \times 10^{-2}\ T$

(ii) Ans magnetic field strength, $B = 6.5\ G = 6.5 \times 10^{-4}\ T$
speed of the elec., $v = 4.8 \times 10^{6}\ m/s$
charge on elec, $e = 1.6 \times 10^{-19}\ C$
mass of elec, $m_e = 9.1 \times 10^{-31}\ kg$

Angle b/w the elec. and mag. field,
$\theta = 90°$

$F = eVB\sin\theta$
∴ Centripetal force
$F_c = mv^2/r$

In Equilibrium, the centripetal force,
$F_c = F$

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(13) (a)

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

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

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

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

(12) Ans Mag. field strength, $B = 6.5 \times 10^{-4} T$
charge of elec, $e = 1.6 \times 10^{-19} C$
mass of elec, $m_e = 9.1 \times 10^{-31} kg$
velocity of elec, $V = 4.8 \times 10^{6} m/s$
Radius, $r = 4.2 cm = 0.042 cm$
frequency of revolution
$\omega = 2\pi v$.
Velocity of the electron is related
$V = r\omega$.

(b)

$eVB = mV^2/r$.

$eB = \frac{m}{r}(r\omega) = \frac{m}{r}(r 2\pi v)$

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

(14)

$v = \frac{6.5 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$
$\approx 18 MHz$

∴ frequency, is 18 MHz

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(13) (a) no. of turns of circular coil, $n = 80$
radius, $r = 8\,cm = 0.08\,m$

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

current flowing, $I = 6A$
mag. field strength, $B = 1T$
Angle $(\theta = 60°)$

$T = nIBA\sin\theta$
$= 36 \times 6 \times 1 \times 0.0201 \times \sin 60°$
$= 3.133\,Nm$

(b) It can be inferred for relation
(i) that the magnitude of the applied torque is not dependant on the shape of coil. It depends on the area of the coil. Hence, the answer would not change if the circular coil in the above case.

(14) Radius of coil X, $r_1 = 16\,cm = 0.16\,m$
" " coil Y, $r_2 = 10\,cm = 0.1\,m$
no of turns on X, $n_1 = 20$
no. of turns on Y, $n_2 = 25$

Current in coil, X, $I_1 = 16A$
" " ", Y, $I_2 = 18A$

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

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where,

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

$= 4\pi \times 10^{-4}$ T (towards East)

Magnetic coil Y,

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

$$= \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.10}$$

$= 9\pi \times 10^{-4}$ T (towards West)

∴ net magnetic fields

$B = B_2 - B_1$

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

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

$= 1.57 \times 10^{-3}$ T (towards West)

(15) Ans magnetic field strength,

$B = 100G = 100 \times 10^{-4}$ T

no. of turns / length, $n = 1000$ turns/m

Current flowing in coil, $I = 15$ A

permeability, $\mu_0 = 4\pi \times 10^{-7}$ Tm/A

$B = \mu_0 n I$

$\therefore nI = B/\mu_0$

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

≈ 8000 A/m

If the length of the coil is taken as 50 cm, $r = 4$ cm, no of turns 400, Page

current 10A, then these values are not unique for given purpose. There's always a possibility.

(17) (a) Magnetic field outside a toroid is zero. It's non-zero only ~~outside~~ inside the core of a toroid.

(b) Magnetic field inside the core of a toroid is given by the relation,

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

where,

l = length of toroid.

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

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

$$= 0.51\pi$$

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

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

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

(18) (Ans) (a) initial velocity of the particle is either parallel/anti-parallel to the magnetic field.

Hence, it travels along a straight path without suffering any deflection

(b) Yes, the final speed of the charged particle will be equal to it's initial speed.
This is because magnetic force can change the dirn. of velocity, but not it's magnitude.

(c) An electron travelling for West to East enters a chamber having a uniform electrostatic field in north-south direction.
This moving electron can remain undeflected if electric force acting on it's equal and opposite of mag. field.

(19)(Ans)

magnetic field strength, $B = 0.15T$
charge of on the elec. $e = 1.6 \times 10^{-19}$ C.
mass of elec., $m = 9.1 \times 10^{-31}$ kg.
potential diff., $V = 2kV, 2 \times 10^{3}$ V.
K.E of electron $= eV$

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

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

where,
v = velocity of electron.

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(a) magnetic force on the electron provides the required centripetal force of the electron. Hence, electron traces a circular path of radius (r)

~~B = ev~~ BeV

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

$\therefore Bev = mv^2/r$

$r = \frac{mv}{Be}$ ...... (2)

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

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

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

$= 1.01 \times 10^{-3}\,m \approx 1mm$

$\therefore$ electron has a circular trajectory of radius 1.0mm normal.

(b) when the field makes, θ of 30°

$v_1 = v\sin\theta$

$r_1 = \frac{mv_1}{Be} = \frac{mv\sin\theta}{Be}$

$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}}\left[\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{5}}{9 \times 10^{-31}}\right]^{1/2} \times \sin\theta$

$= 0.5 \times 10^{-7} m$

$= 0.5 mm.$

(20) magnetic field, $B = 0.75 T$.

Acc. voltage, $V = 15 kV = 15 \times 10^3 V$.

elec. field, $E = 9 \times 10^5 V/m$

mass of electron = m.

charge of electron = e.

velocity of the electron = v

kinetic energy of the electron = eV.

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

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

$\therefore eE = evB$

$v = E/B$ ... (2)

Putting eq. (2) in eq. (1).

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

$$= \frac{(9.10 \times 10^5)^2}{2 \times 1500 \times (0.75)^2} = 4.8 \times 10^7 C/kg$$

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(27) magnetic field strength, $B = 3000\ G$,
$3000 \times 10^{-4}\ T = 0.3T$
length of rect. loop, $l = 10\ cm$
width of rect. 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, $I = 12A$

(a) Torque, $\vec{\tau} = I\vec{A} \times \vec{B}$
it can be observed that A is ⊥ to the y-z and B is directed along z-axis.

$\therefore \tau = 12 \times (50 \times 10^{-4})\hat{i} \times 0.3\hat{k}$
$= -1.8 \times 10^{-2}\hat{j}\ N\text{-}m$.

(b) The case is similar to case (a).
∴ the answer is the same as (a).

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

$\therefore \tau = -12 \times (50 \times 10^{-4})\hat{j} \times 0.3\hat{k}$
$= -1.8 \times 10^{-2}\hat{j}\ N\text{-}m$.
— Torque is $1.8 \times 10^{-2}\ N\text{-}m$ along the -x-direction

(d) Magnitude of torque is given as:
$|\tau| = IAB$
$= 12 \times 50 \times 10^{-4} \times 0.3$
$= 1.8 \times 10^{-2}\ N\text{-}m$
Torque is $1.8 \times 10^{-2}\ N\text{-}m$ at an

angle of 270° with (+ve) x-direction.

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

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

$= 0$.

Hence, the torque is zero

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

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

$= 0$

$\therefore$ Torque is zero

(27) Ans Resistance of the galvanometer coil, $G = 12\Omega$

Current for full scale deflection,

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

Range of volt-meter is 0, which needs to be converted to 18V.

$\therefore V = 18V$

Let a resistor of resistance R be connected in series with galvanometer

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

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

Hence a resistor of resistance 5988Ω is to connected in series with the galvanometer