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Chapter 4 Magnetic Effect of Current.

① $N = 100$, $r = 8cm = 0.08 m$, $I = 0.40A$

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

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

② Here, $I = 35A$, $r = 20 cm = 0.2 m$

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

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

⑥ $l = 3.0cm = 0.03m$, $I = 10A$

$\theta = 90°$, $B = 0.27 T$.

$$F = IlB \sin\theta = 10 \times 0.03 \times 0.27 \times \sin 90°$$

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

The direction of force is given by Flemings left hand rule.

⑦ Force per unit length of each wire

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

Force on 10 cm section of wire A is

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

⑧ number of turns per unit length of the solenoid is

$$n = \frac{\text{Number of turns per layer} \times \text{Number of layers}}{\text{Length of solenoid}}$$

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

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Magnetic field inside the solenoid is –

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

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

(11) ∴ Magnetic force on the electron = Centripetal force.

$$evB \sin 90° = \frac{m_e v^2}{r}$$

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

Now $B = 6.5 G = 6.5 \times 10^{-4}$ T, $v = 4.8 \times 10^6$ m/s.

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

$= 4.2$ 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.

The frequency f does not depend on the speed v of the electron.

(13) $N = 30$, $r = 8.0$ cm $= 0.08$ m, $I = 6.0$ A.

$B = 1$ T, $\theta = 60°$

Magnitude of deflecting torque

= magnitude of the counter torque

$= NIBA \sin\theta$

$= 30 \times 6 \times 1 \times (3.14 \times 0.08 \times 0.08) \sin 60°$

$= 30 \times 6 \times 3.14 \times 64 \times 10^{-4} \times 0.866 = 3.1$ Nm

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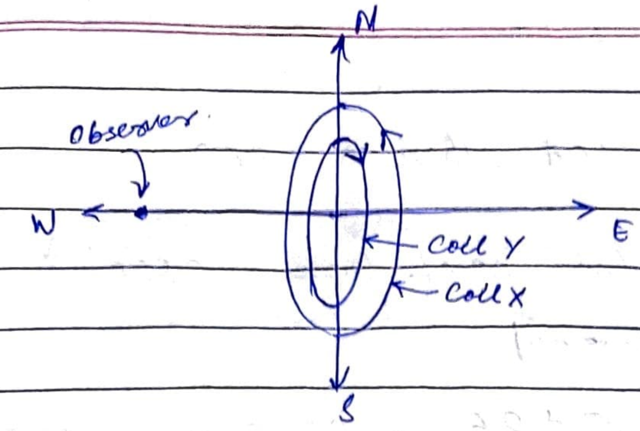

For coil X : $r_x = 16$ cm $= 0.16$ m , $N_x = 20$, $I_x = 16$ A.

∴ magnetic field at the centre of coil X is

$$B_x = \frac{\mu_0 I_x N_x}{2 r_x} = \frac{4\pi \times 10^{-7}}{2} = \frac{16 \times 20}{0.16} \text{ T}$$

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

As the current in the coil X is anticlockwise, the field is directed towards east.

For coil Y : $r_y = 10$cm $= 0.10$ m , $N_x = 25$, $I = 18$ A

∴ magnetic field at the centre of coil Y is.

$$B_y = \frac{\mu_0 N_y I_y}{2 r_y} = \frac{4\pi \times 10^{-7}}{2} = \frac{18 \times 25}{0.10} \text{ T}$$

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

$$B = B_y - B_x$$

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

$$= 1.6 \times 10^{-3} \text{ T}$$

(15) Here $B = 100$ G $= 10^{-2}$ T , $I = 15$A

$n = 1000$ turns m^{-1}

Magnetic field inside solenoid $B = \mu_0 n I$

$nI = B/\mu_0 = 10^{-2} / 4\pi \times 10^{-7}$

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$= 2955 \approx 8000$

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

(17) Here $I = 11A$, total no of turns $= 3500$

mean radius of toroid

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

Circumference of toroid $= 2\pi r$

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

$\therefore$ No 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 surrounds by the toroid is also zero.

(18) (a) The force on a charged particle moving in a magnetic field is

$$F = qvB \sin\theta$$

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

$$\sin\theta = 0 \text{ or } \theta = 0°, 180°$$

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 not work on it. So the charged particle will have its final speed equal to its initial speed.

c) The electron travelling west to east experiences a force towards north due to the electrostatic field. It will remain undeflected if it experiences an equal force towards south due to the magnetic field.

(20) $B = 0.75\,T$, $E = 9.0 \times 10^5\ V/m$.

$V = 15\,kV = 15 \times 10^3\ V$

For undeflected beam, velocity of charged particles must be

$$v = \frac{E}{B} = \frac{9.0 \times 10^5}{0.75}\ m/s = 12 \times 10^5\ m/s.$$

Kinetic energy of charged particle

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

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

$$= 4.8 \times 10^7\ C/kg.$$

For deuterons,

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

This means that the particles may be deuterons, each of which contains one proton and one neutron.

Other possible answers are He^{2+} and Li^{3+} etc.

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(22) $I_1 = I_2 = 300 A$, $r = 1.5 cm = 1.5 \times 10^{-2} m$.

$l = 70 cm = 0.70 m$.

Force per unit length of between the wires is

$$f = \frac{\mu_0 I_1 I_2}{2\pi r} = \frac{4\pi \times 10^{-7} \times 300 \times 300}{2\pi \times 1.5 \times 10^{-2}} N/m$$

$= 1.2 N/m$.

Total force between the wire are in opposite direction the force is repulseive.

(27) Here $R_g = 12 \Omega$.

$I_g = 3 mA = 3 \times 10^{-3} A$, $V = 18 V$

$$R = \frac{V}{I_g} - R_g = \frac{18}{3 \times 10^{-3}} - 12$$

$= 6000 - 12 = 5988 \Omega$.

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

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

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

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

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