Moving Charges and Magnetism
Exercise - 4

1- $n = 100$

$r = 8.0cm = 0.08m$

$I = 0.4A$

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

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

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

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

2- $I = 35A$

$r = 20cm = 0.2m$

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

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

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

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

6- $l = 3cm = 0.03m$

$I = 10A$

$B = 0.27T$

$\theta = 90°$

$F = BIl \sin\theta$

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

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

7- Current flowing in wires A, $I_A = 8.0A$

Current flowing in wires B, $I_B = 5.0A$

$r = 4.0cm = 0.04m$

$l = 10cm = 0.1m$

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

$$= \frac{4\pi \times 10^{-7} \times 2 \times 8 \times 5 \times 0.1}{4\pi \times 0.04}$$ $(\mu_0 = 4\pi \times 10^{-7} TmA^{-1})$

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

8- $l = 80cm = 0.8cm$

$N = 5 \times 400 = 2000$

$D = 1.8cm = 0.018m$

$I = 8.0A$

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

$$= \frac{4\pi 10^{-7} \times 20008}{0.8}$$

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

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

11- $B = 6.5G = 6.5 \times 10^{-4} T$

$v = 4.8 \times 10^{6} m/s$

$e = 1.6 \times 10^{-19} C$

$m_e = 9.1 \times 10^{-31}$ kg

$\theta = 90^\circ$

$F = evB\sin\theta$

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

$F_c = F$

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

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

$= 4.2 cm$

12- $B = 6.5 \times 10^{-4}$ T

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.1 \times 10^{-31}$ kg

$v = 4.8 \times 10^{6}$ m/s

$r = 4.2 cm = 0.42$ m

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

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

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

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

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

$= 18$ MHz

13(a) $n = 30$

$r = 5\ cm = 0.05\ m$

Area of coil $= \pi r^2 = \pi (0.05)^2 = 0.0201\ m^2$

$I = 6.0\ A$

$\theta = 60^\circ$

$\tau = nIBA \sin\theta$ —— (1)

$= 30 \times 6 \times 1 \times 0.0201 \times \sin 60^\circ$

$= 3.133\ Nm$

b. It can be inferred from relation (i) 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.

14- $r_1 = 16\ cm = 0.16\ m$

$r_2 = 10\ cm = 0.1\ m$

$n_1 = 20$

$n_2 = 25$

$I_1 = 16\ A$

$I_2 = 15\ A$

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

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

$= 4\pi \times 10^{-6}\,T$ (Toward East)

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

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

$= 9\pi \times 10^{-4}\,T$ (Toward East)

Hence,

$B_{net} = B_2 - B_1$

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

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

$= 1.57 \times 10^{-3}\,T$ (toward west)

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

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

$I = 15A$

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

$B = \mu_0 n I$

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

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

$\approx 8000\,A/m$

17- $r_1 = 25cm = 0.25m$

$r_2 = 26cm = 0.26m$

$N = 3500$

$I = 11A$

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

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

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

$= \pi (0.25 + 0.26)$

$= 0.51\pi$

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

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

c- Magnetic field in the empty space surrounded by the toroid is zero.

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 be equal to its initial speed. This is because magnetic force can change direction of velocity, but not its.

c. An electron travelling from West to East enters a chamber having a uniform electrostatic field in the North - South direction. This moving electron can remain undeflected if the electric force acting on it is equal and opposite of magnetic field. Magnetic force is directed towards the South.

27. $G = 12\Omega$

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

$V = 18V$

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

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

28. $G = 15\Omega$

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

$I = 6A$

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

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

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