CHIRANJIB DASH, XII DB, 9882

Moving Charges And Magnetism

1) $n = 100$

$r = 8.0\ cm = 0.08\ m$

$I = 0.4\ A$

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

where

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

$|B| = \frac{4\pi \times 10^{-7}\ TmA^{-1}}{4\pi} = 3.14 \times 10^{-4}\ T$

2) $I = 35\ A$

$r = 20\ cm = 0.2\ m$

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

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

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

6) $l = 3\ cm = 0.03\ m$

$I = 10\ A$

$B = 0.27\ T$

$\theta = 90°$

$F = BIl \sin\theta$

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

$= 8.1 \times 10^{-2}\ N$ (Magnetic force)

7) $I_A = 8.0\ A$

$I_B = 5.0\ A$

$r = 4.0\ cm = 0.04\ m$

$l = 10\,cm = 0.1\,m$.

$B = \frac{\mu_0 2 I_A I_B l}{4\pi r} = 2\times10^{-5}\,N$. (Force on a 10 cm section of wire A).

8) $l = 80\,cm = 0.8\,m$.
There are five layers of 400 turns each of the solenoid.
So $N = 5\times400 = 2000$
D (diameter) $= 0.018\,m$.
$I = 8.0\,A$

$B = \frac{\mu_0 N I}{l} = \frac{4\pi\times10^{-7}\times2000\times8}{0.8} = 2.512\times10^{-2}\,T$

11) $B = 6.5\,G = 6.5\times10^{-4}\,T$
$v = 4.8\times10^{6}\,m/s$
$e = 1.6\times10^{-19}\,C$
$m_e = 9.1\times10^{-31}\,Kg$
$\theta = 90°$

$F = evB\sin\theta$
This force provides centripetal force to moving electrons.
$F_c = \frac{mv^2}{r}$

In equilibrium
$F_c = F$
$\frac{mv^2}{r} = evB\sin\theta = 4.2\times10^{-2}\,m = 4.2\,cm$.

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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 $= 0.042$ m.

Frequency of the electron $= \nu$

Angular frequency of the electron $= \omega = 2\pi\nu$.

$v = r\omega$

In circular orbit, the magnetic force on the electron is balanced by the centripetal force. Hence we can write

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

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

$$\nu = \frac{Be}{2\pi m} = 18 \text{ MHz}$$

14) $r_1 = 0.16$ m

$r_2 = 0.1$m.

$n_1 = 20$

$n_2 = 25$.

$I_1 = 16$ A

$I_2 = 18$A

$$B_1 = \frac{\mu_0 n_1 I_1}{2r_1} = 4\pi \times 10^{-4} \text{ T (towards east}$$

$$B_2 = \frac{\mu_0 n_2 I_2}{2r_2} = 9\pi \times 10^{-4} \text{ T (towards west)}$$

$$B = B_2 - B_1$$
$$= 1.57 \times 10^{-3} \text{ T (towards west)}$$

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

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

$I = 15A$

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

$B = \mu_0 n I$

$nI = \frac{B}{\mu_0} = \frac{100 \times 10^{-4}}{4\pi \times 10^{-7}} = 7957.74\, A/m$

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

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

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

Here $l = 2\pi\left[\frac{r_1 + r_2}{2}\right] = 0.51\pi$

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

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

18) a) The initial velocity of 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

initial speed. This is because magnetic force can change the direction of velocity, but not its magnitude

19) $B = 0.15 T$

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

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

$V = 2.0$ KV $= 2 \times 10^{3}$ V

Thus kinetic energy of the electron = eV

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

$v = \sqrt{\frac{2eV}{m}}$ —— (i)

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

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

$r = \frac{mv}{Be}$ —— (ii)

from (i) & (ii)

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

$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}}\left(\frac{2.16 \times 10^{-19} \times 2 \times 10^{3}}{9.1 \times 10^{-31}}\right)^{\frac{1}{2}}$

$= 1$ mm.

24) $B = 3000$ G $= 0.3$ T

$l = 10$ cm.

$b = 5$ cm

Area of loop $= l \times b = 50 \times 10^{-4}$ m^2

$I = 12$ A

Now taking the anticlockwise direction as positive

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

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

$= -1.8 \times 10^{-2}\hat{j}$ Nm. (negative y direction)

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

b) Similar to (a)

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

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

$= -1.8 \times 10^{-2}\hat{j}$ Nm. (negative x direction)

The force is zero

d) $|\tau| = IAB.$

$= 1.8 \times 10^{-2}$ Nm (along positive x direction)

The force is zero

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

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

$= 0$

Hence the torque is zero. The force is zero

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

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

$= 0$

Hence the force is also zero.

In case (e) the equilibrium is stable

27) $G = 12\,\Omega$

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

$V = 18\,V$

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

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

28) $G = 15\ \Omega$

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

$I = 6\,A$

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

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

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

$$\approx 0.01\ \Omega = 10\ m\Omega$$