Moving Charges and Magnetism

1. Number of turns = 100
radius = 8.0 cm
current = 0.40 A

Magnetic field of B = ?

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

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

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

2. Current = 35 A
20 cm from the point = 0.2 m

B = ?

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

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

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

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4·3. $I = 50A$

$r = 2.5m$

$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 50 \times 10}{2\pi \times 2.5}$

$= ~~4 \times 10~~ \; 4.0 \times 10^{-6} T$

4·4. $I = 90A$

$~~r~~ = 1.5m$

$B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 90 \times 10}{2\pi \times 1.5}$

$= 12 \times 10^{-6} T$

4·5 $I = 8A$

$\theta = 30^\circ$

$B = 0.15T$

$F = ~~l~~ BI \sin\theta$

~~F = B sin θ~~

$\Rightarrow ~~8\times~~ \; 0.15 \times 8 \times \sin 30^\circ$

$= \frac{4 \times 15}{100} = \frac{3}{5} = 0.6 \, N m^{-1}$

$L = 3\,cm = 0.03\,m$

4.6 $I = 10\,A$

$B = 0.27\,T$

$F = ?$

~~$B = \mu_0 I$~~

$F = BI \sin\theta \quad (\theta = 90^\circ)$

$F = \frac{27}{100} \times 10 \times \frac{3}{100} \sin 90^\circ$

$\Rightarrow \frac{27}{100} \times 10 \times \frac{3}{100} \times 1$

$\Rightarrow 81 \times 10^3$

$= 8.1 \times 10^2\,N$

4.7 $I_A = 8.0\,A$

$I_B = 5.0\,A$

$r = 4.0\,cm = 0.04\,m$

length of section of wire $A = l = 10\,cm = 0.1\,m$

~~$\theta = 180^\circ$~~ $\theta = 180^\circ$

$B = \frac{\mu_0 2 I_1 I_2 L}{4\pi r} =$

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

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

4.8 Length of the solenoid (L) = 80 cm = 0.8 m
Total number of turns (N) = 5 × 400 = 2000
Diameter of the solenoid (D) = 1.8 cm = 0.018 m
Current carried by solenoid I = 8.0 A
Magnitude of magnetic feild

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

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

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

$$= 8 \times \frac{22}{7} \times 10^{-3}$$

$$= \frac{176}{7} \times 10^{-3}$$

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

4.9 $L = 10\ cm = 0.1\ m$
$I = 12\ A$
$n = 20$
$\theta = 30^\circ$
$B = 0.80\ T$
$\tau = ?$

$$\tau = nBIA \sin\theta$$

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$\Rightarrow 20 \times 0.8 \times 12 \times 0.01 \times \sin 30^\circ$ ($A = 0.1 \times 0.1 = 0.01 m^2$)

$\Rightarrow \overset{10}{\cancel{20}} \times 0.8 \times 12 \times 0.01 \times \frac{1}{\cancel{2}}$

$\Rightarrow 8 \times 12 \times \frac{1}{100}$

$= \frac{96}{100} = 0.96\ Am$

4.10 For M_1

$R_1 = 10\Omega$

$N_1 = 30$

$A_1 = 3.6 \times 10^{-3} m^2$

$B_1 = 0.25 T$

$K_1 = K$

For M_2

$R_2 = 14\Omega$

$N_2 = 42$

$A_2 = 1.8 \times 10^{-3} m^2$

$B_2 = 0.50 T$

$K_2 = K$

a) Current sensitivity of M_1

$I_1 = \frac{N_1 B_1 A_1}{K_1}$

Current sensitivity of M_2

$I_2 = \frac{N_2 B_2 A_2}{K_2}$

Ratio $= \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times K}{30 \times 0.25 \times 3.6 \times 10^{-7} \times K} = 1.4$

Voltage sentivity of M1 :

$$V_1 = \frac{N_1 B_1 A_1}{K_1 R_1}$$

Voltage sentivity of M2

$$V_2 = \frac{N_2 B_2 A_2}{K_2 R_2}$$

$$\text{Ratio} = \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times 10 \times K}{30 \times 0.25 \times 3.6 \times 10^{-3} \times 14 \times K}$$

$$= 1$$

4.11 $B = 6.5 \times 10^{4}$ T
$V = 4.8 \times 10^{0}$ m/s
radius = ?

~~qB = Centripetal force~~

$$R = \frac{mV}{qB} = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{1.5 \times 10^{-19} \times 6.5 \times 10^{-4}}$$

$$= \frac{91 \times 10^{-30} \times 4.8 \times 10^{4}}{1.5 \times 10^{-19} \times 6.5 \times 10^{-4}}$$

$$= \frac{91 \times 10^{-8} \times 48 \times 10^{4}}{1.5 \times 6.5}$$

$$= \frac{91 \times 48 \times 10^{4}}{15 \times 65 \times 10^{2}} = 4.48 \times 10^{2}$$

4.12 $f = \frac{qB}{2\pi m}$

$= \frac{1.5 \times 10^{-19} \times 6.5 \times 10^{-4}}{2\pi \times 9.1 \times 10^{-31}}$

4.13 a) $N = 30$

$r = 8$ cm $= 0.8$ m Area $= \pi r^2 = 0.02\ m^2$

$I = 6A$

$B = 1.0\ T$

$\theta = 60°$

$\tau = NBIA \sin\theta$

$= 30 \times 6 \times 1 \times 0.02 \times \sin 60°$

$= 3.1$ Nm

b) No as it depends upon area of the coil hence the answer would not change

4.14

Coil X	Coil Y
$r_1 = 16$ cm $= 0.16$ m	$r_2 = 10$ cm $= 0.1$ m
$n_1 = 20$	$n_2 = 25$
$I_1 = 16A$	$I_2 = 18A$
X = anticlockwise	Y = clockwise

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

B coil X	coil Y
$B_1 = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0.16}$	$B_2 = \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.10}$
$= 4\pi \times 10^{-4}$ T (Towards East)	$= 9\pi \times 10^{-4}$ (Towards west

Hence Net magnetic feild =

$B = B_2 - B_1$

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

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

$= 1.57 \times 10^{-3}$ T

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

$n = 1000$ turns

$I = 15$ A

$B = \mu_0 n I$

$\therefore nI = \frac{B}{\mu_0} = \frac{100 \times 10^{-4}}{4\pi \times 10^{-7}} = 8000$ A/m

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4.16 a) at center → $\frac{\mu_0 I}{2R} < \frac{\mu_0 I R^2}{2(R^2 + x^2)^{3/2}}$

b) Radius = r
num of turns = N
both equal current distance = r
at mid point: $B_1 + B_2$

$B = 0.72 \frac{\mu_0 I N}{r}$

4.17) Inner radius r = 25 cm = 0.25 m
Outer radius R = 26 cm = 0.26 m
N = 3500
I = 11 A

a) Magnetic feild outside the toroid is zero.

b) $B = \frac{\mu_0 N I}{L}$
where L is lenght of toiroid

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

$= \pi (0.25 + 0.26)$

$= 0.51\pi$

$\therefore B = \frac{4\pi \times 10^{-7} \times 3500 \times 11}{0.51\pi} = 3.0 \times 10^{-2}$ T

c) Magnetic feild in empty space surrounded by toroid is zero

4.19 a) Charge particle moves in straight line path

b) Final speed = Initial speed

c) If electric feild is equal and opposite to magnetic feild then charge particle moves unaffected

4.20 $B = 0.75T$

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

$E = 9 \times 10^5 Vm$

Mass of electron = m

charge of electron = -e

velocity " " = v

Kinetic energy of electron = eV

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

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

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$eE = evB$ (Particle remains unaffected)

$v = \frac{E}{B}$ —②

putting (2) in (1) we get

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

$= \frac{(9.0 \times 10^5)^2}{2 \times 15000 \times (0.75)^2} = 4.8 \times 10^4 \, C/Kg$

4.21 a) $l = 0.45m$

$m = 60g = 60 \times 10^{-3} \, Kg$

$g = 9.8 \, m/s$

$I = 5A$

$\therefore BIL = mg$

$B = \frac{mg}{IL}$

$= \frac{60 \times 10^{-3} \times 9.8}{5 \times 0.45} = 0.26T$

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4.22) $I = 300\,A$

$r = 1.5\,cm = 0.015\,m$

$L = 70\,cm = 0.7\,m$

$F = \dfrac{\mu_0 I^2}{2\pi r}$

$F = \dfrac{4\pi \times 10^{-7} \times (300)^2}{2\pi \times 0.015} = 1.2\,N/m$

~~4.24~~

4.24 $B = 3000\,G = 3000 \times 10^{-4}\,T = 0.3\,T$

$I = 12\,A$

$b = 5\,cm$

$l = 10\,cm$

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

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

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

b) ~~The answer~~

c)

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4.25 $n = 20$
$r = 10cm = 0.1m$
$B = 0.10T$
$I = 5.0A$

a) The total tourque on the coil is zero
b) Total force on the coil is zero
c) cross sectional Area $A = 10^{-9} m^2$
Number of free electron per cubic meter
$N = 10^{29}/m$

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

$F = BeV_d$ (Vd is drift velocity)

$$V_d = \frac{1}{NeA}$$

$$\therefore F = \frac{BeI}{NeA}$$

$$= \frac{0.10 \times 5.0}{10^{29} \times 10^{-5}} = 5.0 \times 10^{-23} N$$

4.27 $G = 12\Omega$
$I_g = 3mA = 3 \times 10^{-2} A$
$V = 18V$

$$R = \frac{V}{I_g} - G = \frac{18}{3 \times 10^{-2}} - 12 = 6000 - 12 = 5988

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

4.28 $I_g = 4mA = 4 \times 10^{-3}$ A

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

$\therefore$ $I = 6A$

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

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

$$\Rightarrow \frac{6 \times 10^{-2}}{6 - 0.004} = \frac{0.06}{5.996} = 0.01\,\Omega$$

$$= 10 m\Omega$$