Home Assignment

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

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

hence,

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

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

The magnitude of the magnetic field is $3.14 \times 10^{-4}\, T$

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

where

μ_0 = Permeability of free space

$= 4\pi \times 10^{-7}\, T m A^{-1}$

Substituting the values in the equation,

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

$= 3.5 \times 10^{-5}\, T$ (Ans)

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

where

μ_0 = Permeability of free space.

$= 4\pi \times 10^{-7}\, T m A^{-1}$

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

The point is located normal to the wire length at a distance of 2 km. The direction of the current in the wire is vertically downward. Hence, according to Maxwell's right-hand thumb rule, the direction of the magnetic field at the given point is vertically upward.

4. $|B| = \dfrac{\mu_0 2I}{4\pi r}$

where,

μ_0 = Permeability of free space
$= 4\pi \times 10^{-7}\ \mathrm{Tm\,A^{-1}}$

Substituting the values,

$$|\overline{B}| = \frac{4\pi\times10^{-7}}{4\pi} \times \frac{2\times 90}{1.5}$$

$$= 1.2 \times 10^{-5}\ \mathrm{T}$$

The current flows from East to West. The point is below the electrical cable. Hence, according to Maxwell's right-hand thumb rule, the direction of the magnetic field is towards the south.

5. The magnetic force per unit length on the wire is given as $F = BI\sin\theta$

$= 0.15 \times 8 \times 1 \times \sin 30^\circ$

$= 0.6\ \mathrm{N\,m^{-1}}$

Hence, the magnetic force per unit length on the wire is $0.6\ \mathrm{N\,m^{-1}}$.

at a distance of 1.5 m. The direction of the current in the wire is vertically downward. Hence, according to Maxwell's right-hand thumb rule, the direction of the magnetic field at the given point is vertically upward.

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

where,

μ_0 = Permeability of free space

$= 4\pi \times 10^{-7}\ \mathrm{T\,m\,A^{-1}}$

Substituting the values,

$$|\vec{B}| = \frac{4\pi \times 10^{-7}}{4\pi} \times \frac{2 \times 90}{1.5}$$

$$= 1.2 \times 10^{-5}\ \mathrm{T}$$

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Hence, the magnetic force per unit length on the wire is $0.6\ \mathrm{N\,m^{-1}}$.

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6. $F = BIl \sin\theta$

Substituting the values in the above equation, we get.

$= 0.27 \times 10 \times 0.03 \times \sin 90^\circ$
$= 8.1 \times 10^{-2} N$

Hence, the magnetic force on the wire is 8.1×10^{-2} N
The direction of the force can be obtained from Fleming's left-hand rule.

7. $F = \dfrac{\mu_0 I_A I_B L}{2\pi r}$

where
μ_0 = Permeability of free space
$= 4\pi \times 10^{-7} T m A^{-1}$
Substituting the values, we get.

$F = \dfrac{4\pi \times 10^{-7} \times 8 \times 5 \times 0.1}{2\pi \times 0.04}$
$= 2 \times 10^{-5} N$
The magnitude of force is 2×10^{-5} N. This is an attractive force normal to A towards B because the direction of the currents in the wires is the same.

8. $B = \dfrac{\mu_0 N I}{l}$

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

$B = \dfrac{4\pi \times 10^{-7} \times 2000 \times 8}{0.8} = 2.5 \times 10^{-2} T$ (Ans)

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9. $\tau = nBIA \sin\theta$

where,

A = Area of square coil

$= l \times l$

$= 0.1 \times 0.1$

$= 0.01 m^2$

So, $\tau = 20 \times 0.8 \times 12 \times 0.01 \times \sin 30^\circ$

$= 0.96 Nm$

Hence, 0.96 Nm is the magnitude of the torque experienced by the coil.

10 (a) current sensitivity of M_1 is given as:

$$I_{g1} = \frac{N_1 B_1 A_1}{K_1}$$

And, current sensitivity of M_2 is given as

$$I_{g2} = \frac{N_2 B_2 A_2}{K_2}$$

$\therefore$ Ratio $\frac{I_{g2}}{I_{g1}} = \frac{N_2 B_2 A_2}{N_1 B_1 A_1} = \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times K}{K \times 30 \times 0.25 \times 3.6 \times 10^{-3}} = 1.4$

Hence, the ratio of current sensitivity of M_2 to M_1 is 1.4.

b) voltage sensitivity of M_2 is given as:

$$V_{g2} = \frac{N_2 B_2 A_2}{K_2 R_2}$$

And, voltage sensitivity of M_1 is given as:

$$V_{g1} = \frac{N_1 B_1 A_1}{K_1 R_1}$$

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$\therefore$ Ratio $\frac{Fg_2}{Fg_1} = \frac{N_2 B_2 A_2 K_1 R_1}{N_1 B_1 A_1 K_2 R_2} = \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times 10 \times K}{K \times 14 \times 30 \times 0.25 \times 3.6 \times 10^{-3}}$

$= 1$

Hence ratio of voltage sensitivity of M_2 to M_1 is 1

10. $R_1 = 10\,\Omega$, $N_1 = 30$.
$A_1 = 3.6 \times 10^{-3}\, m^2$
$B_1 = 0.25\, T$
$R_2 = 14\Omega$, $N_2 = 42$
$A_2 = 1.8 \times 10^{-3}\, m^2$, $B_2 = 0.5\, T$

~~(a) I.~~

11. The relation for Magnetic force exerted on the electron in the magnetic field
$= F = evB \sin\theta$

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

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

$\Rightarrow r = \frac{mv}{eB\sin\theta}$

So,
$r = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90^\circ} = 4.2 \times 10^{-2}\, m = 4.2\, cm$

12. In the circular orbit, the magnetic force on the electron is balanced by the centripetal force
Hence,
$\frac{mv^2}{r} = evB$

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

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

$\Rightarrow \nu = \frac{6.5\times10^{-4}\times1.6\times10^{-19}}{2\times3.14\times9.1\times10^{-31}} = 1.82\times10^{6}\,H$

$= 18\,MHz$

(a) No. of turns on the circular coil $(n) = 30$

Radius of coil $= 8.0\,cm = 0.08\,m$

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

Current flowing in the coil $= 6.0\,A$

$\Rightarrow T = nIBA\sin\theta$

$= 30\times6\times1\times0.0201\times\sin60°$

$= 3.133\,Nm$

(b) It can be inferred from the relation $T = nIBA\sin\theta$ that the magnitude of the applied torque is not dependent on ~~the~~ 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.

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15. Magnetic field is given as,

$B = \mu_0 N I / l$

$\Rightarrow$ $NI/l = B/\mu_0$

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

$\frac{NI}{l} = 7961$

Now, we can consider a possible combination. Let the current, $I = 10\,A$ and length of the solenoid l = 0.5m

So we get,

$\frac{(N \times 10)}{0.5} = 7961$

$\therefore$ $N = 398$ turns $= 400$ turns

Length about 50 cm, number of turns about 400, current about 10A. These particulars are not unique some adjustment with limits is possible.

16. (a) Given, $B = \frac{\mu_0 I R^2 N}{2(x^2+R^2)^{3/2}}$

At the centre of the coil, $x = 0$

Therefore, the magnetic field at the centre is $B = \frac{\mu_0 I R^2 N}{2R^3}$

$B = \frac{\mu_0 I N}{2R}$

b) $B = \frac{\mu_0}{4\pi} \left\{ \frac{2\pi n I a^2}{(x^2+a^2)^{3/2}} \right.$

$$B = \frac{\mu_0}{2} \frac{n I a^2}{(x^2+a^2)^{3/2}}$$

$$B_1 = \frac{\mu_0}{2} \frac{N I R^2}{\left(\left(\frac{\pi}{2}+d\right)^2+R^2\right)^{3/2}}$$

$$B_1 = \frac{\mu_0}{2} \frac{N I R^2}{\left(\left(\frac{\pi^2}{4}+d^2+Rd\right)R^2\right)^{3/2}}$$

d^2 can be neglected when compared to R^2

$$B_1 = \frac{\mu_0 N I R^2}{2} \frac{1}{\left(\frac{3R^2}{4}\right)^{3/2}} \left[(1+4d/5R)^{-3/2}\right]$$

$$B_2 = \frac{\mu_0}{2} \frac{N I a^2}{(x_2^2+R^2)^{3/2}}$$

$$B_2 = \frac{\mu_0}{2} \frac{N I R^2}{\left(\left(\frac{R}{2}-d\right)^2+R^2\right)^{3/2}}$$

$$B_2 = \frac{\mu_0 N I R^2}{2} \frac{1}{\left(\frac{3R^2}{4}\right)^{3/2}} \left[(1-4d/5R)^{-3/2}\right]$$

$$B = \frac{\mu_0 N I R^2}{2} \left[\left(1+\frac{4d}{5R}\right)^{-3/2} + \left(1-\frac{4d}{5R}\right)^{-3/2}\right]$$

$$B = \frac{\mu_0 N I R^2}{2\left(\frac{3\pi^2}{4}\right)^{3/2}} \times 2$$

$$B = \frac{\mu_0 N I R^2}{2\left(\frac{3\pi^2}{4}\right)^{3/2}} \times 2$$

$$B = \frac{\mu_0 N I}{R} \left(\frac{4}{5}\right)^{3/2}$$

$$B = (0.75) \frac{\mu_0 N I}{R}$$

~~17. (a)~~

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17(a) The magnetic field outside the toroid is zero.

(b) Inside the core of the toroid, the magnetic field induction is

$B = \mu_0 N I / l$

Mean length of the toroid,

$l = 2\pi\left(\frac{r_1 + r_2}{2}\right)$

$= \pi(r_1 + r_2) = \pi(0.25 + 0.26) = \pi \times 0.51$

So, $B = \mu_0 N I / l$

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

$= 3.02 \times 10^{-2} T$

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

18(a) Initial velocity is either parallel or anti-pa to the magnetic field. There is no magnetic forc acting on the particle when it is parallel or anti parallel and it moves undeflected.

(b) Yes, because magnetic force can change the direc of velocity but not its magnitude.

(c) Magnetic field should be in a vertically downward direction.

19(a) The forces F_1 and F_2 are equal.

$\Rightarrow$ $r = \frac{9.1 \times 10^{-31} \times 2.652 \times 10^{7}}{0.15 \times 1.6 \times 10^{-19}} = 10^{-3} m = 1 mm$

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(b) $r = mv \sin\theta / Be$

$$r = \frac{9.1 \times 10^{-31} \times 2.652 \times 10^{7} \times \sin 30^\circ}{0.15 \times 1.6 \times 10^{-19}}$$

$= 50.25 \times 10^{-5} m$

$= 0.5 mm$

20. The particles are not deflected by the electric field and the magnetic field. So the force on the particle due to the electric field is balanced by the force due to the magnetic field.

$eE = evB$

$\therefore$ $v = E/B$

Therefore, $(1/2) m (E/B)^2 = eV$

$$e/m = \frac{E^2}{2VB^2}$$

$$= \frac{(9.0 \times 10^5)^2}{2 \times 15000 \times (0.75)^2} = 4.8 \times 10^7 C/Kg$$

The beam contains Deuterium ions or deuterons.

21(a) $BIl = mg$

$B = mg/Il$

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

$= 0.2613 T$

(b) $T = BIl + mg$

$= (0.26133 \times 5.0 \times 0.45) + (60 \times 10^{-3} \times 9.8) = 0.587 + (0.588)$

$= 1.176 N$

22. $F = \mu_0 I^2 / 2\pi d$

μ_0.

Here,

μ_0 = permeability of the free space $= 4\pi \times 10^{-7}$ Tm

$$F = \frac{4\pi \times 10^{-7} \times (300)^2}{2\pi \times 0.015}$$

$= 1.2$ N/m

Since the direction of the wires are opposite, the force will be repulsive.

23 (a) The wire intersects the axis, $\theta = 90^\circ$

$F = BIl \sin\theta = 1.5 \times 7 \times 0.20 \times \sin 90^\circ$

$= 2.1$ N

(b) ~~The~~ wire is turned from N-S to northeast northwest direction is $I_1 = I/\sin\theta$

Therefore, $I = l_1 \sin\theta$

$F = BIL$

$= 1.5 \times 7 \times 0.20$

$= 2.1$ N

(c) When the wire is lowered by 6 cm,

Then $x = \sqrt{(10)^2 - (6)^2} = \sqrt{64} = 8$ cm

$2x = l_2 = 16$ cm

$F_2 = BIl_2 = 1.5 \times 7 \times 0.16$

$= 1.68$ N

The force is directed vertically downwards.

Ans(a) $\vec{T} = I\vec{A} \times \vec{B}$

$\vec{A} = 50 \times 10^{-4} \hat{i}$

$\vec{B} = 0.3 \hat{k}$

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

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

The torque is 1.8×10^{-2} Nm along the negative y-direction. The net force on the loop is zero since the opposite forces acting on the two ends of the loop will cancel each other.

(b) This is same as (a). Therefore, the torque is 1.8×10^{-2} Nm along the negative y-direction. The net force is zero.

(c) $\vec{A} = -50 \times 10^{-4} \hat{j}$

$\vec{B} = 0.3 \hat{k}$

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

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

(d) $\vec{T} = I\vec{A} \times \vec{B}$

$\Rightarrow T = 12 \times 50 \times 10^{-4} \times 0.3$

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

From positive X-axis the net force on the loop is zero.

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(e) $\vec{A} = 50 \times 10^{-4} \hat{k}$

$\vec{B} = 0.3 \hat{k}$

Accordingly,

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

$= 0$

Hence, force is zero.

(f) $\vec{A} = -50 \times 10^{-4} \hat{k}$

$\vec{B} = 0.3 \hat{k}$

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

$= 0$

Therefore, torque and force is zero.

25(a) total torque on the coil

$\vec{T} = NI\vec{A} \times \vec{B}$

$\Rightarrow \tau = NIAB \sin 0 = 0$

(b) Equal and opposite forces are acting on opposite sides of the coil. Therefore, the total force on the coil is zero.

(c) $F = Bev_d$

$v_d = I/NeA$

$\Rightarrow F = BeI/NeA$

$\Rightarrow F = BI/nA = \frac{0.1 \times 5}{10^{29} \times 10^{-5}} = 5 \times 10^{-25}$ N

26. $\mu_0 = 4\pi \times 10^{-7}$

$B = (4\pi \times 10^{-7}) \times 1500 \times I$

$= 6\pi \times 10^{-4} I$ —— (1)

Force due to magnetic field, $F = I'Bl$

I' = Current in the wire = 6A

l = Length of the wire = 2cm

$I'Bl = mg$

$\Rightarrow B = mg / I'l$

From eqn (1),

$6\pi \times 10^{-4} I = mg / I'l$

$$I = \frac{2.5 \times 10^{-3} \times 9.8}{6 \cdot 0.02 \times 4\pi \times 10^{-7} \times 1500} = 108.37 \text{ A}$$

27 $R = (V/I_g) - G$

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

$= 6000 - 12 = 5988\ \Omega$

A galvanometer can be converted into a voltmeter by connecting a resistor of $5988\ \Omega$

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

Therefore, $S = \frac{4 \times 10^{-3} \times 15}{6 - 0.004} = 10 \times 10^{-3}$ A $= 10$ mA

A 10 mA resistor must be connected in parallel to the galvanometer