1. No. of turns on the circular coil, $n = 100$
Radius of each turn, $r = 8.0\ cm = 0.08\ m$
Current flowing in the coil, $I = 0.4A$

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

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

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

2. Current in the wire, $I = 35A$
$r = 20\ cm = 0.2\ m$

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

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

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

6. ~~I = 3cm = 0.03m~~
$l = 3\ cm = 0.3\ m$
$I = 10\ A$
$B = 0.27\ T$
$\theta = 90^\circ$

$$F = BIl \sin\theta$$

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

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

7. $I_A = 8.0\ A$, $I_B = \cancel{8.0}\ 5.0\ A$
$r = 4.0\ cm = 0.04\ m$
$l = 10\ cm = 0.1\ m$

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

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

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

8. $l = 80 cm = 0.8 m$

Total no. of turns on the solenoid, $N = 5 \times 400 = 2000$

$D = 1.8 cm = 0.018 m$

$I = 8.0 A$

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

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

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

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

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

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

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

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

$\theta = 90^\circ$

$$F_e = \frac{mv^2}{r}, \quad F_e = F$$

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

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

$$= 4.2 \times 10^{-2} m$$

$$= 4.2 cm$$

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 $= 0.042$ m

$\omega = 2\pi \nu$

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

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

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

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

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

$$\approx 18 \text{ MHz}$$

13.

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

Radius of the coil, $r = 8.0$ cm $= 0.08$ m

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

$I = 6.0$ A

$B = 1$ T

$\theta = 60°$

$$\tau = nIBA \sin\theta \quad \text{—— (i)}$$

$$= 30 \times 6 \times 1 \times 0.201 \times \sin 60°$$

$$= 3.133 \text{ Nm}$$

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. Radius of coil X, $r_1 = 16\,cm = 0.16\,m$
Radius of coil Y, $r_2 = 10\,cm = 0.1\,cm$
No. of turns of on coil X, $n_1 = 20$
No. of turns of on coil Y, $n_2 = 25$
Current in coil X, $I_1 = 16A$
Current in coil Y, $I_2 = 18A$

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

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

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

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

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

$$= 9\pi \times 10^{-4}\,T \text{ (towards ~~we~~ east)}$$

Net magnetic field, $B = B_2 - B_1$

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

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

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

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

$n = 1000$

$I = 15\ A$

$\mu_0 = 4\pi \times 10^{-7}\ T m A^{-1}$

$B = \mu_0 n I$

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

$= \dfrac{100 \times 10^{-4}}{4\pi \times 10^{-7}} = 7657.74$

$\approx 8000\ A/m$

17.

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

b) $B = \dfrac{\mu_0 N I}{l}$

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

$= \pi\ (0.25 + 0.26)$

$= 0.51\pi$

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

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

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 magnitude.

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 underflected if the electric force acting on it is equal and opposite of magnetic field.

19.

a) Magnetic force on the electron provides the required centripetal force of the electron.

Hence, the electron traces a circular path of radius r. Magnetic force on the electron is given by the relation, BeV

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

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

$V = \sqrt{\frac{2eV}{m}}$ ---- (1)

$r = \frac{mv}{Be}$ ---- (2)

From eq (1) and (2), we get

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

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

$$= 100.55 \times 10^{-5}$$

$$= 1.01 \times 10^{-3}\ m$$

$$= 1\ mm$$

b) When the field makes an angle θ of $30°$ with initial velocity, the initial velocity will be,

$V_1 = v \sin\theta$

From eq (2), we can write the expression for new radius as:

$$V_1 = \frac{mv_1}{Be}$$

$$= \frac{mv \sin\theta}{Be}$$

$$= \frac{9.1 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left(\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9 \times 10^{-31}}\right) \times \sin 30°$$

$$= 0.5 \times 10^{-3}\ m$$

$$= 0.5\ mm$$

20. $B = 0.75\ T$

$V = 15\ KV = 15 \times 10^{3}\ V$

$E = 9 \times 10^{5}\ Vm^{-1}$

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

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

Since the particles remains undeflected by electric and magnetic fields, we can infer that the electric field is balancing the magnetic field.

$\therefore eE = evB$

$v = \dfrac{E}{B}$ —— (2)

Putting eq (2) in eq (1), we get

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

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

This value of specific charge e/m is equal to the value of deuteron or deuterium ions. This is not a unique answer. Other possible answers are He^{++}, Li^{+++}.

24. $B = 3000 G = 3000 \times 10^{-4} T = 0.3 T$

$l = 10 cm$

$b = 5 cm$

Area of the loop,

$A = l \times b = 10 \times 5 \, cm^2 = 50 \times 10^{-4} m^2$

$I = 12 A$

Now, taking the anti-clockwise direction of the current as positive and vice-versa:

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

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

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

The torque is 1.8×10^{-2} Nm along the negative y-direction.

The force on the loop is zero.

b) Same as (a)

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

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

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

It is along negative x direction and the force is 0.

d) $|\tau| = IAB$

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

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

τ is 1.8×10^{-2} Nm at an angle of 240° with positive x direction. The force is zero.

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

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

$= 0$

27. $G = 12\ \Omega$

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

$V = 18$ V

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

$= 6000 - 12$

$= 5988\ \Omega$

28. $G = 15\ \Omega$

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

$I = 6A$

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

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

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

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