Chapter-14 | Exercise Short Questions.

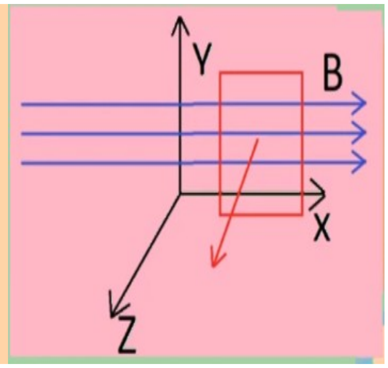
14.1

A plane conducting loop is placed in a magnetic field that is directed along the x axis. For what orientation of the loop is the flux a minimum?

Minimum Flux:

- When loop is held such that normal at plane of loop is perpendicular to field.
- Angle between normal and magnetic field is 90^0

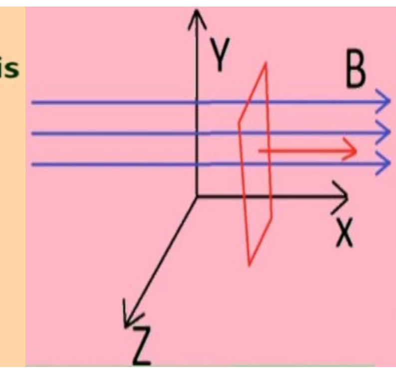
$$\emptyset = BA\cos\theta$$
$$= BA\cos 90^0$$
$$= BA(0)$$
$$= 0(minimum)$$



Maximum Flux:

- When loop is held such that normal at plane of loop is parallel to field (along x axis).
- Angle between normal and magnetic field is 0^0

$$\emptyset = BA\cos\theta$$
$$= BA\cos 0^0$$
$$= BA(1)$$
$$= BA(maximum)$$



14.2

A current in a conductor produces a magnetic field, which can be calculated using Ampere's law. Current is defined as the rate of flow of charge, what can you conclude about the magnetic field due to stationary charges? What about moving charges?

Magnetic field due to stationary charges is zero.

Reason:

- Rate of flow of stationary charges is zero.
- So current due to stationary charges is zero.

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

$$= \frac{\mu_0 (0)}{2\pi r}$$

$$= 0$$

Magnetic field due to moving charges is non zero.

Reason:

- **Since moving charges in flow.**
- **And current exists due to flow of charges so**

$$I \neq 0$$

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

$$\neq 0$$

14.3

Describe the change in magnetic field inside a solenoid carrying a steady current I, if a) length of solenoid is doubled but the number of turns remains the same and b) the number of turns is doubled but the length remains the same.

a) The magnetic field will become half

Reason:

- **The magnetic field inside the solenoid is given as**

$$B = \mu_0 n I$$

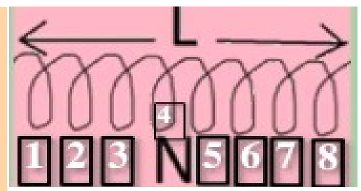
- **Where n is the number of turns per unit length**

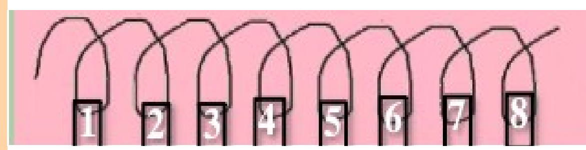
$$n = \frac{N}{L}$$

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

$$B' = \mu_0 \frac{N}{2L} I = \frac{1}{2}\left(\mu_0 \frac{N}{L} I\right) = \frac{1}{2} B$$

$$B' = \frac{1}{2} B$$





b) The magnetic field will become double

Reason:

- **The magnetic field inside the solenoid is given as**

$$B = \mu_0 n I$$

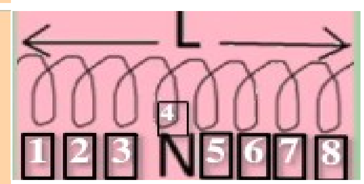
- **Where n is the number of turns per unit length**

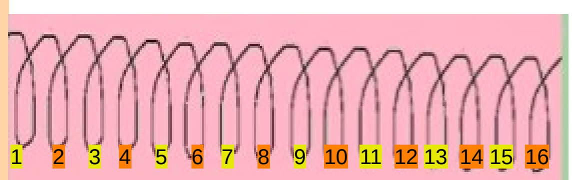
$$n = \frac{N}{L}$$

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

$$B' = \mu_0 \frac{2N}{L} I = 2\left(\mu_0 \frac{N}{L} I\right) = 2B$$

$$B' = 2B$$





14.4

At a given instant, a proton moves in the positive X-direction in a region where there is magnetic field in the negative Z-direction. What is the direction of the magnetic fore? Will the proton continue to move in the positive X-direction? Explain

Initially magnetic force will be along +Y-axis. Proton will move in circle.

Explanation:

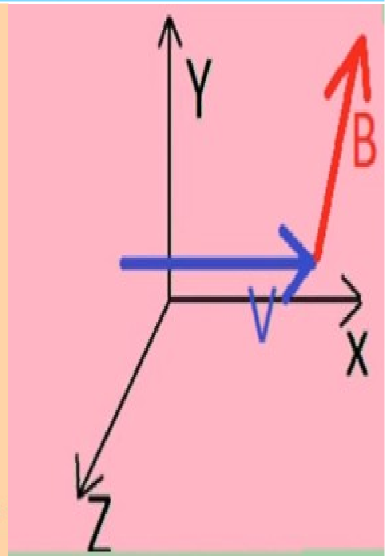
- As we know that

$$\vec{F} = q(\vec{v} \times \vec{B})$$

- Since charge is moving along x direction, $\vec{v} = v\hat{i}$
- And magnetic field is along –Z direction, $\vec{B} = -B\hat{k}$

$$\vec{F} = q(v\hat{i} \times (-B\hat{k})) = qvB\left(\hat{i} \times (-\hat{k})\right)$$
$$= qvB(\hat{k} \times \hat{i}) = qvB\hat{j}$$

Hence initially force will be along Y-axis which deflects the charge particle to move in circle.



14.5

Two charge particles are projected in a region where there is magnetic field perpendicular to their velocities. If the charges are deflected in opposite direction, what can you say about them?

These are opposite charges.

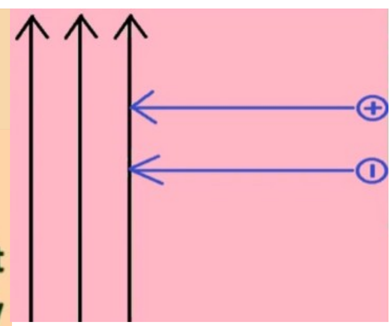
Reason:

- As magnetic force on charge particle is given as

$$\vec{F} = q(\vec{v} \times \vec{B})$$

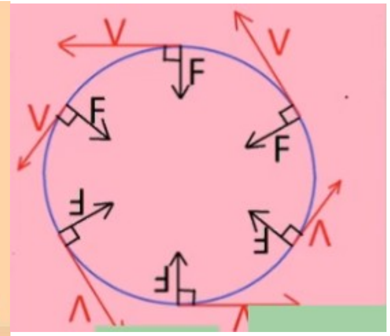
- Since the charge are deflected in opposite direction it means force on them is opposite in sign which is only possible if they are unlike charges.
- For example proton and electron.

$$\vec{F} = e(\vec{v} \times \vec{B})$$
$$\vec{F} = -e(\vec{v} \times \vec{B})$$



14.6

Suppose that a charge particle is moving in a uniform magnetic field with a velocity v. Why is there no work done by the magnetic force that acts on the charge?



<u>Because magnetic force is always perpendicular to velocity.</u>

<u>Reason:</u>

- As magnetic force on charge particle is given as

$$\vec{F} = q(\vec{v} \times \vec{B})$$

- From properties of cross product it is always perpendicular to velocity.
- As displacement and velocity are parallel to each other so magnetic force is also perpendicular to displacement.

$$W = Fd\cos\theta = Fd\cos 90^0 = 0$$

- Hence this force only deflects the particle and do no work.

14.7

If a charge particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero?

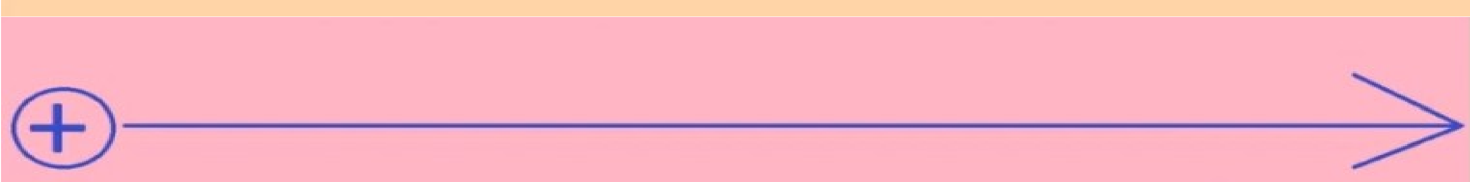
<u>No, It is not necessary.</u>

<u>Reason:</u>

- As magnetic force on charge particle is given as

$$\vec{F} = q(\vec{v} \times \vec{B}) = qvB\sin\theta$$

- If charge is moving parallel or anti parallel to field. There will be no force by magnetic field on the charge particle.
- So charge particle will move in a straight line even in the presence of magnetic field.



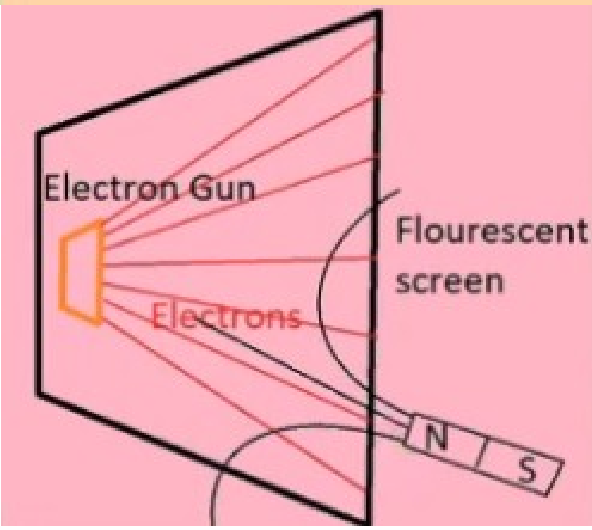
14.8

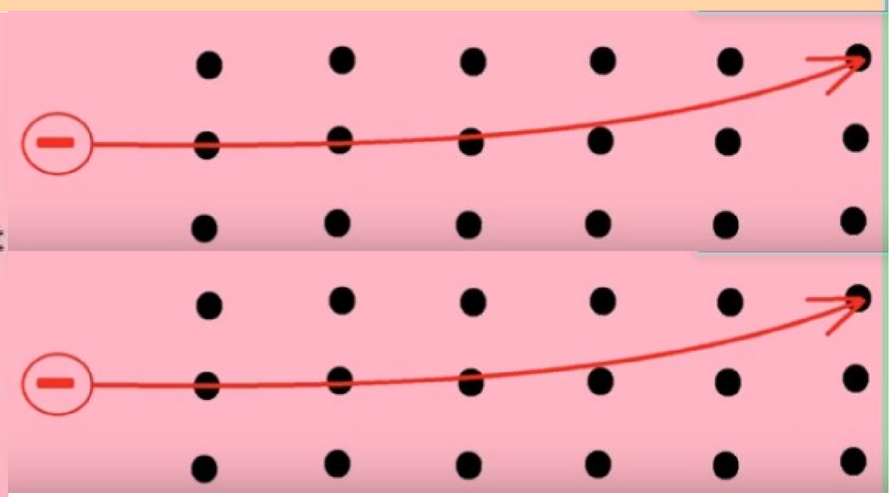
Why does the picture on a TV screen become distorted when a magnet is brought near the screen?

Due to deflection of electrons in magnetic field.

Explanation:

- Picture on TV screen is formed by beam of electrons.
- When magnet is brought near the screen the magnetic force deflects the electrons from original path.





14.9

Is it possible to orient a current loop in a uniform magnetic field so that the loop will not tend to rotate? Explain.

Yes, it is possible.

Explanation:

- Loop will not tend to rotate if torque on the current loop is zero.
- The torque on the loop is given as.

$$\tau = NAIBcos\alpha$$

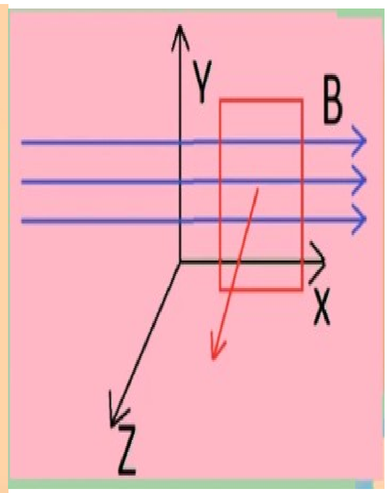
- If normal at plane of loop is perpendicular to the field,

$$\alpha = 90^0$$

$$cos90^0 = 0$$

$$\tau = 0$$

- Hence loop will not tend to rotate.



14.10

How can a current loop be used to determine the presence of magnetic field in a given region of space?

- Suspend a current loop freely where the magnetic field is to be determined.
- If at some orientation it feels a torque and start to rotate.
- The magnetic field is present in that region of space.

14.11

How can you use magnetic field to separate isotopes of a chemical element?

- Ions of single element are passed through uniform and perpendicular magnetic field.
- Magnetic field provides them centripetal force and ions moves in circles.

$$r = \frac{mv}{qB}$$

- Since v, q and B are all constants, so

$$r \propto m$$

- Hence every isotope has radius different from others and in this way they are separated.