CHAPTER NO. 14 (ELECTROMAGNETISM)

Question 14.1:- A plane conducting loop is located in a uniform magnetic field that is directed along x-axis. For what orientation of the loop is the flux a maximum? For what orientation is the flux a minimum?

Answer:- The magnetic flux through a plane conducting loop of area A is given by $\phi = \vec{B}.\vec{A}$ = B A cos θ where $\vec{B}$ is magnetic flux density, $\vec{A}$ is vector area which points normally outward of a plane and θ is the angle between $\vec{B}$ and $\vec{A}$.

CASE 1:- When the magnetic flux density and area vector are parallel to each other, $\theta = 0^o$, the flux is maximum and given as $\phi_{max} = B\ A \cos 0^o = BA$.

CASE 2:- When the magnetic flux density and area vector are perpendicular to each other, $\theta = 90^o$, the flux is minimum and is given as $\phi_{min} = B\ A \cos 90^o = 0$.

Question 14.2:- A current in a conductor produces a magnetic field, which can be calculated using Ampere's law. Since 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?

Answer:- The rate of flow of charge with respect to time is called current.

Since, stationary charges do not constitute a current, hence no magnetic field is produced by stationary charges.

Moving charges produce a current, therefore, a magnetic field is produced around the path of motion of charges similar to the magnetic field produced around a current carrying conductor.

Question 14.3:- Describe the change in magnetic field inside a solenoid carrying a steady current I, if (a) the length of the solenoid is doubled but the number of turns remain the same and (b) the number of turns is doubled, but the length remains the same.

Answer:- The magnetic field inside a solenoid is $B = \mu_o n I = \mu_o \frac{N}{L} I$.

(a) When length of the solenoid is doubled and number of turns remain the same, we can say $L_1 = 2L$. We can calculate magnetic field as $B_1 = \mu_o \frac{N}{L_1} I = \mu_o \frac{N}{2L} I = \frac{B}{2}$.

The magnetic field is reduced to half of its initial value.

(b) When the number of turns is doubled but the length remains the same, we can say $N_2 = 2N$. We can calculate magnetic field as $B_2 = \mu_o \frac{N_2}{L} I = \mu_o \frac{2N}{L} I = 2B$

The magnetic field is increased to double of its initial value.

Question 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 force? Will the proton continue to move in the positive x direction? Explain.

Answer:- When a proton moves along positive x-axis and magnetic field is directed along z-axis, the force on the proton according to the relation $\vec{F} = q\,(\vec{v}\; x\; \vec{B})$ is directed along y-axis. Mathematically, we can prove as following:-

$\vec{v} = v\,\hat{\imath}$, $\vec{B} = -B\,\hat{k}$, hence $\vec{F} = -q\,(v\,\hat{\imath}\; x\; B\,\hat{k}) = qvB\,\hat{\jmath}$ as $\hat{\imath}\; x\; \hat{k} = -\hat{\jmath}$.

No, the proton will not continue to move along x-axis. It will be deflected in a circular path in xy-plane.

Question 14.5:- Two charge particles are projected into a region where there is a magnetic field perpendicular to their velocities. If the charges are deflected in the opposite directions,

What can you say about them?

Answer:- When a charged particle enters in a magnetic field perpendicularly, a deflecting force perpendicular to the plane containing the direction of motion and magnetic field is applied on them according to relation $\vec{F} = q\,(\vec{v}\; x\; \vec{B})$.

If two charged particles enter in a magnetic field perpendicularly and are deflected in opposite directions, both particles are oppositely charged i.e. one is positively charged and other is negatively charged.

Question 14.6:- Suppose that a charge q 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 q?

Answer:- The magnetic force on the charged particle always acts perpendicular to the direction of motion of the particle according to the relation $\vec{F} = q\,(\vec{v}\; x\; \vec{B})$.

The work done by the magnetic force on the charged particle is $W = \vec{F}.\vec{d} = F\,d\cos\theta = F\,d\cos 90^o = 0$. No work is done by magnetic force on the moving charged particles.

Question 14.7:- If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in the region is zero?

Answer:- No, the magnetic field may or may not be zero.

The magnitude of magnetic force acting on a charge is $F = qvB \sin \theta$. If a charged particle moves in a straight line through some region of space, there are two possibilities:-

- **a)** The magnetic field is zero in this region
- **b)** The magnetic field is directed parallel or anti-parallel to the direction of movement of charge.

Question 14.8:- Why does the picture on a TV screen become distorted when a magnet is brought near the screen?

Answer:- The picture on a TV screen is formed by striking a beam of electrons on a fluorescent screen. When a magnet is brought near the TV screen, it applies a deflecting force on beam of electron and picture on TV screen is distorted.

Question 14.9:- Is it possible to orient a current loop in a uniform magnetic field such that the loop will not tend to rotate? Explain.

Answer:- The torque on a current carrying loop of N turns placed in a magnetic field is $\tau = NIAB \cos \alpha$ where α is the angle between plane of the loop and the magnetic field.

If we place a stationary current carrying loop in a magnetic field such that plane of the loop is perpendicular to the magnetic field, the torque acting on it will be $\tau = NIAB \cos 90^o$ and it will not tend to rotate.

Question 14.10:- How can a current loop be used to determine the presence of a magnetic field in a given region of space?

Answer:- A current carrying loop when placed in a magnetic field experiences a torque according to relation $\tau = NIAB \cos \alpha$ where α is the angle between plane of the loop and the magnetic field.

If current carrying loop experiences a deflection in a certain region of space, the magnetic field is present in this region.

If current carrying loop does not experience any deflection when placed at all possible angles, the magnetic field in this region is zero.

Question 14.11:- How can you use a magnetic field to separate isotopes of chemical element?

Answer:- If singly ionized ions of an isotope are projected perpendicularly in a magnetic field with same velocity, a deflecting force compels them to move in a circular path of radius r according to following relation:-

evB = $\frac{m\,v^2}{r}$ and r = $\frac{mv}{qB}$ which implies that r α m.

Hence isotopes of different masses will have different radii of curvature and will be separated.

Question 14.12:- What should be the orientation of a current carrying loop in a magnetic field so that torque acting on the coil is (a) maximum (b) minimum?

Answer:- A current carrying loop when placed in a magnetic field experiences a torque according to the relation $\tau = NIAB \cos \alpha$, where α is the angle between plane of the loop and the magnetic field.

(a) If plane of the current carrying loop is placed parallel to the magnetic field, the torque acting on the loop will be maximum as $\alpha = 0^\circ$ and $\tau = NIAB \cos 0^\circ = NIAB$.

(b) If plane of the current carrying loop is placed perpendicular to the magnetic field, the torque acting on the loop will be minimum as $\alpha = 0^\circ$ and $\tau = NIAB \cos 90^\circ = 0$.

Question 14.13:- A loop of wire is suspended between the poles of a magnet with its plane parallel to pole faces. What happens if a direct current is put through the coil? What happens if an alternating current is used instead?

Answer:- The magnetic field lines originate perpendicularly from flat pole faces of the magnet. When a loop of wire is suspended between the poles of a magnet with its plane parallel to pole faces, the angle α between plane of the loop and magnetic field will be 90° and torque acting on the loop will be zero as $\tau = NIAB \cos \alpha = NIAB \cos 90^\circ = 0$.

Hence, no torque will act on the loop for both DC and AC.

Question 14.14:- Why the resistance of an ammeter should be very low?

Answer:- An ammeter is always connected in series with a circuit to measure the current. It is connected in series with a circuit so that all the current of the circuit may pass through it. If resistance of the ammeter will be large, it will decrease the current of the circuit and measurement will not be accurate.

Question 14.15:- Why the voltmeter should have a very high resistance?

Answer:- A voltmeter is always connected in parallel with a resistor or load to measure potential difference across it. Its resistance must be very large so that it does not draw a considerable amount of current and current of the circuit almost remains constant & measurement of the potential difference will be accurate.