

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

Give Short Answers of the Following Questions

1. If a charged particle 'q' is moving in a region with velocity v where there is an electric field E and magnetic field B , find total force (Lorentz force) on the particle?

Ans. When a charge particle enters into a region where both electric and magnetic fields are present then the resultant force experienced by the charged particle is combined effect of electric force and magnetic force exerted on charged particle is called Lorentz force.

Mathematically,

$$\vec{F} = \vec{F}_e + \vec{F}_m$$

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

2. How fast must be a proton moving in a magnetic field of $2.50 \times 10^{-3} \text{ T}$ such that the magnetic force is equal to its weight?

Ans. Magnetic force = weight

$$F = W$$

$$qvB = mg$$

Or
$$v = \frac{mg}{qb}$$

Putting values, we get

$$v = \frac{1.67 \times 10^{-27} \times 9.8}{1.60 \times 10^{-19} \times 2.50 \times 10^{-3}} = \frac{16.366 \times 10^{-27}}{4 \times 10^{-22}}$$

$$v = 4.09 \times 10^{-5} \text{ ms}^{-1}$$

3. The magnetic field in a certain region is given by $\vec{B} = (40\hat{i} - 18\hat{k}) \text{ Wbm}^{-2}$. How much flux passes through a 5.0 cm^2 area loop in this region if the loop lies flat in the XY - plane?

Ans. Magnetic induction = $\vec{B} = (40\hat{i} - 18\hat{k}) \text{ Wbm}^{-2}$

$$\text{Area of the loop} = \Delta\vec{A} = 5.00 \text{ cm}^2 \hat{k} = 5.0 \times 10^{-4} \text{ m}^2 \hat{k}$$

Magnetic flux = $\phi_B = ?$

$$\phi_B = \vec{B} \cdot \Delta\vec{A}$$

$$\phi_B = (40\hat{i} - 18\hat{k}) \cdot (5.0 \times 10^{-4} \hat{k})$$

$$\phi_B = (40)(0) - (18 \times 5 \times 10^{-4})$$

$$\phi_B = 0 - 90 \times 10^{-4} \text{ Wb}$$

$$\phi_B = -90 \times 10^{-4} \text{ Wb}$$

4. Define electromagnetic induction.

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

Ans. If the magnetic field through a circuit changes, an emf and a current are induced in the circuit. This phenomenon is called electromagnetic induction.
If a conductor moves through a magnetic field then due to change in magnetic flux, an emf is induced known as induced emf. If the circuit is closed, it will cause an electric current called induced current.

5. How the induced current can be increased?

Ans. The induced current can be increased by the following ways.

- By increasing the speed of the coil
- By increasing the strength of the field
- By increasing the number of turns of the coil
- By decreasing the resistance of the coil.

6. Name four method to produced emf?

Ans. Induction due to Motion of loop across the magnetic field.
Induction due to Motion of Magnet towards or away from the coil.
Induction due to Changing the Area of Coil across the magnetic field.
Induction due to Rotation of Coil across the magnetic field.

7. An A metal rod of length 25 cm is moving at speed of 0.5ms^{-1} in a direction perpendicular to a 0.25 T magnetic field. Find the emf produced in the rod.

Ans. As motion emf is given by the formula

$$\varepsilon = vBL$$

Putting the values, we get

$$\varepsilon = 0.5 \times 0.25 \times 0.25$$

$$\varepsilon = 0.0313 \text{ V}$$

Or $\varepsilon = 3.13 \times 10^{-2} \text{ V}$

8. A charge is lying stationary between the opposite poles of two magnets. Is a magnetic force exerted on it? Why?

Ans. No, a magnetic force is not exerted on the stationary charge.

Reason:

As magnetic force on a charged particle can be expressed as,

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

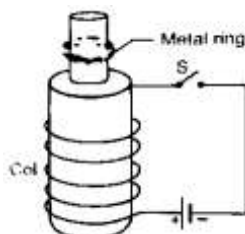
$$F = qv B \sin \theta$$

If $v = 0$, then $F = 0$

Magnetic forces only act on moving charges. Since the charge is stationary, there is no magnetic force exerted on it, regardless of the strength of the magnetic field.

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

9. When the switch in the circuit is closed, a current is established in the coil and the metal ring jumps upward. Why? Describe what would happen to the ring if the battery polarity were reversed?



Ans. (a) Reason:

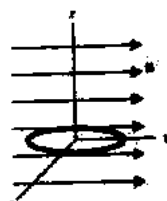
When the switch is closed, the current through coil increases from zero to a maximum steady value. So, the magnetic flux through ring is increased which produces an emf in the ring. (By Faraday's law)

This induced emf acts to decrease the magnetic flux through ring. (By Lenz's law) That is why ring jumps upward.

(b) Reason:

When the polarity of battery is reversed again, the magnetic flux through ring is increased, which produces an emf in the ring. By Lenz's law the ring again jumps upward to decrease the magnetic flux through it.

10. The figure shows a coil of wire in the x-y plane with a magnetic field directed along the y-axis. Around which of the three-coordinate axis should the coil be rotated in order to generate an emf and a current in the coil?



Ans. If the coil is rotated about x-axis an emf and current is generated in the coil.

Reason:

The magnetic flux through the coil changes only when we rotate it about x-axis.

So according to Faraday's law of electromagnetic induction, $\varepsilon = -N \frac{\Delta\phi}{\Delta t}$ emf and current is induced in the coil.

There is no change of magnetic flux when we rotate it around y-axis or z-axis and so no emf is induced.

11. Is it possible to change both the area of the loop and the magnetic field passing through the loop and all not have an induced emf in the loop? Give reason.

Ans. Yes, it is possible.

Explanation:

Magnetic flux through an area is,

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

$$\Phi_B = \vec{B} \cdot \vec{A}$$

So, if we change both $\vec{B}$ and $\vec{A}$ of loop in such a way that product of two remains constant, then

$$\Phi_B = \text{constant}$$

$$\Delta \Phi_B = 0$$

According to faraday's law

$$\varepsilon = -N \frac{\Delta \Phi}{\Delta t}$$

$$\varepsilon = 0$$

12. Does the application of uniform magnetic field to a moving charged particle result in a change in kinetic energy of the particle? Explain.

Ans. No, the application of a uniform magnetic field does not change the kinetic energy of the moving charged particle

Reason:

The magnetic force acting on a charged particle 'q' is given by

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

As magnetic force is always perpendicular to $\vec{v}$ (i.e., $\vec{d}$)

Therefore, angle between $\vec{F}$ and $\vec{d}$ is 90°

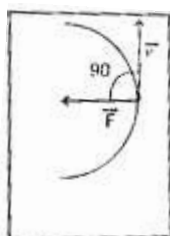
Hence $W = \vec{F} \cdot \vec{d}$

$$W = Fd \cos \theta$$

$$W = Fd \cos 90^\circ$$

$$W = 0$$

So no work is done by magnetic force (deflecting force) and thus not changing its kinetic energy. The particle's path may change direction, but its speed and K.E remains constant.



13. A uniform electric field and a magnetic field act in the same direction. A proton is projected, into the space, with a uniform velocity in opposite direction. What will happen to the proton?

Ans. Electric Force

The proton will slow down due to the electric force, which acts opposite to its velocity.

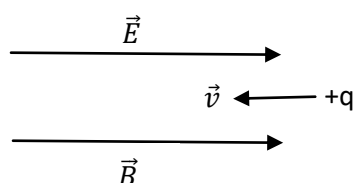
$$F = qE$$

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

Magnetic Force

The magnetic force will be zero since the velocity is parallel to the magnetic field

$$F = qvB \sin \theta \quad qvB \sin 0^\circ = 0$$



- 14. A conductor moves in a magnetic field when a current is passed through the conductor. Would you expect the reverse effect to occur? That is, would a current be produced if a conductor is moved across the magnetic field?**

Ans. Yes, a current can be produced if a conductor is moved across a magnetic field.

According to Electromagnetism (Haan Oersted)

A conductor moves in a magnetic field when a current is passed through the conductor.

$$F = IlB \sin \theta$$

where θ is angle between current and magnetic field)

According to Electromagnetic Induction (Micheal Faraday)

The movement of the conductor through the magnetic field induces an electromotive force (EMF), which drives an electric current in the conductor.

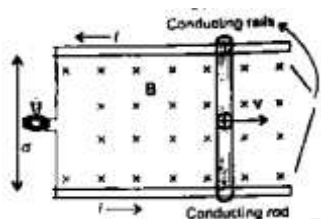
$$\varepsilon = vBl \sin \theta$$

(where θ is angle between velocity and magnetic field)

- 15. Consider a conducting rod of length L moving with velocity v to the right as shown in the figure. Left ends of the conducting rails are connected to a bulb. Due to motion of the rod through the magnetic field, an emf is produced across the ends of the rod. This emf gives rise to a current I . As a result, the bulb lights up. Explain where does the electrical energy consumed by the bulb come from?**

Ans. According to law of conservation of energy, energy can't be created. So, it transforms only from one form to another.

In this case, the electrical energy consumed by the bulb comes from the mechanical energy of the moving rod. The rod's motion through the magnetic field induces an electromotive force (EMF), which drives the current. The magnetic field exerts a force opposing the rod's motion, slowing it down and converting mechanical energy into electrical energy, powering the bulb.



- 16. What will you do if you want to save a sensitive instrument from stray magnetic fields?**

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

Ans. To protect a sensitive instrument from stray magnetic fields, you can enclose it in a mu-metal shield. Mu-metal is a ferromagnetic alloy with high magnetic permeability, which can absorb and redirect magnetic fields, effectively shielding the instrument from stray magnetic fields.

17. It is said that Lenz's law specifically applies to induced currents and not directly to induce emf. Explain it briefly.

Ans. Condition for application of Lenz's law:

We can apply Lenz's law directly to closed loop because it refers to induced currents means for closed circuits only.

As induced current opposes its cause of production (i.e change in flux) and for induced emf, flow of emf is not conditional. So Lenz's law does not applicable directly for induced emf.

However if the loop is not closed we imagine as if it is closed and then from the direction of induced current, we can find the polarity of induced emf.

18. A square loop of wire is moving through a uniform magnetic field. The normal to the loop is oriented parallel to the magnetic field. Is an emf induced in the loop? Give a reason for your answer.

Ans. Reason:

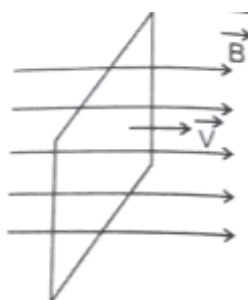
In this case, the magnetic flux through the loop is constant

$$\text{i.e.} \quad \phi = \text{constant} \Rightarrow \Delta\phi = 0$$

Hence, by Faraday's law,

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

$$\Rightarrow \varepsilon = 0$$



19. Does the induced emf always act to decrease the magnetic flux through a circuit?

Ans. No, it always opposes the change in magnetic flux through a circuit.

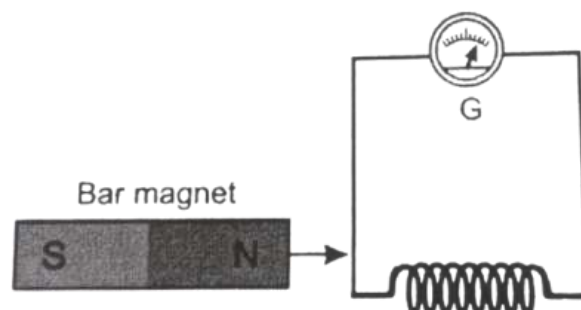
Explanation:

According to Lenz's law, the induced emf always opposes the cause that produces it.

So, if magnetic flux is decreasing through a circuit induced emf acts to increase the magnetic flux through the circuit and vice versa.

20. When a magnet is pushed into the solenoid, as shown in the figure, the galvanometer indicates a small current. Why is the current produced? What will be the magnetic pole produced at the left end of the solenoid?

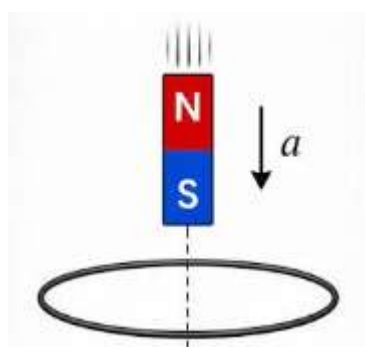
Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------



Ans. According to Faraday's law, when magnet is pushed into solenoid, the emf is induced due to change in magnetic flux, which produces induced current.

According to Lenz's law, when magnet is pushed into the solenoid change in magnetic flux opposes its cause hence, north pole exists at left side of solenoid.

21. A bar magnet falls through a fixed metal ring as shown in figure. Will the magnet fall with acceleration of a freely falling body? Give reason.



Ans. No, the acceleration of magnet is less than g .

Reason:

When the magnet is released, the magnetic flux passing through ring changes and an emf is induced in the ring.

According to Lenz's law, the direction of induced current is such that it opposes the downward motion of magnet. It is possible only when the face of ring towards magnet acts as a south pole. As the magnetic force and gravitational force are opposite. So net force acting on the magnet is less than the gravitational force which causes the acceleration less than gravitational acceleration. (i.e. $a < g$)

22. Which of the two charged particles of the same mass will be deflected most in the magnetic field (a) fast moving (b) slow moving?

Ans. The slow-moving charged particle will be deflected most in the magnetic field.

Reason:

When two charged particles are passed through a uniform and perpendicular field.

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

A magnetic force acts on them. Under the action of this force, the charged particles move along circular paths of different radii due to their different masses as explained below.

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

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

Since m, q and B are constant

$$r \propto v$$

Therefore, a slow-moving particle, the velocity (v) is smaller, resulting in a smaller radius (r) of the circular path. This means the particle with slow speed will be deflected more.

23. An electron and a proton are projected into a magnetic field at right angles to it with a certain velocity. Which of the particles will suffer greater deflection? Why?

Ans. The electron will suffer greater deflection.

Reason:

For this purpose, electron and proton are passed through a uniform and perpendicular field. A magnetic force acts on them.

Under the action of this force, electron and proton move along circular paths of different radii due to their different masses as explained below.

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

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

Since v, q and B are constant

Therefore
$$r \propto m$$

As mass of electron is smaller, so it will deflect into small radius. So deflection (curvature of path) for electron will be more

24. Can a single moving proton produce magnetic field?

Ans. Yes, a single moving proton can produce a magnetic field.

Reason:

According to the principles of electromagnetism, a stationary charged particle can't produce magnetic field whereas a moving charge like a moving proton generates magnetic field.

25. A magnetic field is necessary if there is to be a magnetic flux passing through a coil of wire. Yet just because there is a magnetic field does not mean that a magnetic flux will pass through a coil. Account for this situation.

Ans. A magnetic field is necessary but not sufficient for a magnetic flux to pass through a coil of wire.

Reason:

Magnetic flux is defined as dot product of the magnetic field and the area vector coil.

Chapter	10 Electromagnetism	Class	1 st Year	Subject	Physics
---------	---------------------	-------	----------------------	---------	---------

$$\Phi = \vec{B} \cdot \vec{A} = BA \cos \theta$$

The magnetic field lines must pass through the coil at some angle (not parallel) to the coil's surface for magnetic flux to occur.

If the field lines are parallel to plane of the coil, no magnetic flux will pass through, despite the presence of a magnetic field.

$$\Phi = BA \cos 90^\circ = 0$$