CHAPTER NO. 15 (ELECTROMAGNETIC INDUCTION)

Question 15.1:- Does the induced emf in a circuit depend on the resistance of the circuit? Does the induced current depend on the resistance of the circuit?

Answer:- No, the induced emf in a circuit does not depend on the resistance of the circuit. It depends on the rate of change of magnetic flux through the circuit as $\varepsilon = -N \frac{\Delta\phi}{\Delta t}$.

Yes, the induced current in a circuit depends on the resistance of the circuit as $I = \varepsilon / R = -\frac{N}{R}\frac{\Delta\phi}{\Delta t}$.

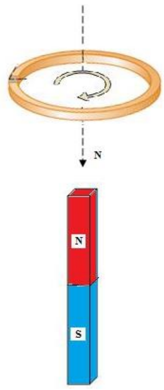
Question 15.2:- A square loop of wire is moving through a uniform magnetic field. The normal to the loop is oriented parallel to the magnetic field. Is a emf induced in the loop? Give reason for your answer.

Answer:- The motional emf in a wire due to magnetic field is given as $\varepsilon = -v B l \sin\theta$. When normal to the loop is oriented parallel to magnetic field, the velocity of the loop is also parallel to the magnetic field.

Hence, $\theta = 0^o$, $\varepsilon = -v B l \sin 0^o = -v B l (0) = 0$

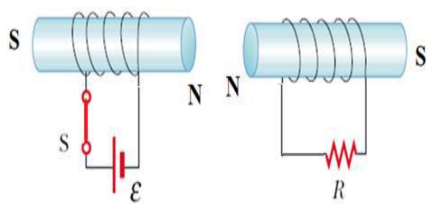
No emf is induced in the loop in the instant case.

Question 15.3:- A light metallic ring is released from above into a vertical bar magnet. Viewed from above, does the current flow clockwise or anticlockwise in the ring?

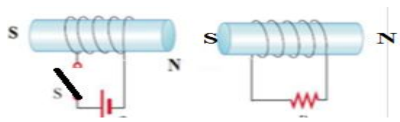


Answer:- According to Lenz's law, the direction of induced current is such as to oppose the change which produced it. When rings falls towards the bar magnet, the flux through the ring increases. Current is induced in clockwise direction so that lower part of the ring appears as north pole as shown in the figure.

Question 15.4:- What is the direction of current through resistor R in figure? When the switch S is (a) closed (b) opened.



Answer:- (a) When the switch is closed, the current in the primary increases from zero to maximum and flux in the secondary coil also increases from zero to maximum. Thus, an induced current is produced in secondary coil. According to



Lenz's law, the induced current in the secondary coil is in anti-clockwise direction.

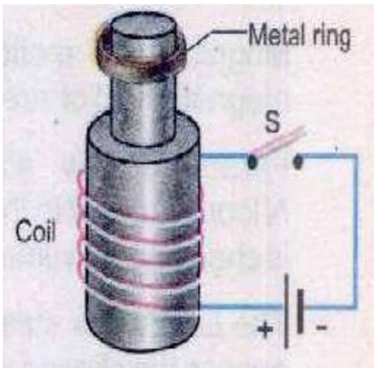
(b) When the switch is opened, the current in the primary decreases from maximum to zero which decreases the magnetic flux through the secondary coil from maximum to zero. An induced current is again produced in the secondary coil. According to Lenz's law, the induced current in the secondary coil is in clockwise direction.

Question 15.5:- Does the induced emf always act to decrease the magnetic flux through a circuit?

Answer:- No, the induced emf does not always act to reduce the magnetic flux through a circuit. According to Lenz's law the induced current always acts to oppose the change which produced it. If magnetic flux through a circuit increases, it acts to decrease it and vice versa.

Question 15.6:- When the witch in the circuit is closed a current is established in the coil and the metal ring jumps upward. Why?

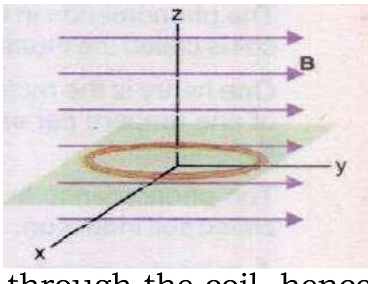
Describe what would happen to the ring if the battery polarity were reversed?



Answer:- When the switch is closed in the circuit, a current is set up in the cylinder and it established magnetic field. In this process, magnetic flux through the copper ring increases, hence an induced current is produced in the metallic ring which opposes the applied magnetic field and the ring jumps upwards.

If the polarity of the battery is reversed, the same would happen again.

Question 15.7:- The figure shows a coil of wire in the xy plane with a magnetic field directed along the y-axis. Around which of the three coordinate axes should the coil be rotated to generate an emf and a current in the coil?



Answer:- i. When the coil is rotated about x-axis, the magnetic flux will keep on changing through it and an induced emf & current will be produced in it.

ii. When the coil is rotated about y-axis, no flux will pass through the coil, hence induced emf and current will be zero.

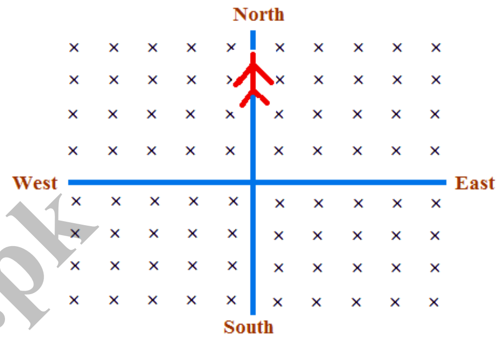
iii. When the coil is rotated about z-axis, no change of flux takes place through the coil, hence induced emf and current will be zero.

Question 15.8:- How would you position a flat loop of wire in a changing magnetic field so that there is no emf induced in the loop?

Answer:- When the plane of the loop of wire is placed parallel to a changing magnetic field, the flux through the coil will not change as $\theta = 0^o$.

The induced emf in a single coil is given as $\varepsilon = \omega A B \sin\theta = \omega A B \sin 0^o = 0$.

Question 15.9:- In a certain region the earth's magnetic field points vertically down. When a plane flies due north, which wingtip is positively charged?



Answer:- The magnetic force on an electron is given by $\vec{F} = -e\,(\vec{v} \times \vec{B})$.

When the planes flies northwards in the earth's magnetic field pointing vertically downwards, the electrons will experience a force eastwards. Thus west wingtip will be positively charged.

Alternately, we can say that $\vec{v} = v\,\hat{j}$, $\vec{B} = -B\,\hat{k}$ and $q = -e$, hence force on electrons is given as $\vec{F} = -e\,(v\,\hat{j} \times -B\,\hat{k}) = qvB\,\hat{\imath}$ as $\hat{j} \times \hat{k} = \hat{\imath}$. Electrons will move towards east wingtip and west wingtip will become positively charged due to deficiency of electrons.

Question 15.10:- Show that ε and $\frac{\Delta\phi}{\Delta t}$ have the same units.

Answer:- The derivation is given as under:-

We know that $\varepsilon = W/q$ Unit of ε = Unit of work / Unit of charge Unit of ε = joule / coulomb = volt	$\Delta\phi/\Delta t = B\,\Delta A / \Delta t$ Unit of $\Delta\phi/\Delta t$ = (unit of B)(Unit of ΔA) / (unit of time) Unit of $\Delta\phi/\Delta t = (N\,A^{-1}\,m^{-1})\,(m^2) / s = N\,m / A\,s$ Unit of $\Delta\phi/\Delta t = J / C = V$

This shows that ε and $\frac{\Delta\phi}{\Delta t}$ have the same units.

Question 15.11:- When an electric motor, such as electric drill, is being used, does it also act as a generator? If so what is the consequence of this?

Answer:- When a motor like a drill machine is working, its armature is revolving in a uniform magnetic field. The flux through the revolving armature changes, which produces an emf, known as back emf of the coil. Hence, a motor or drill also acts as a generator whose emf is called back emf.

Question 15.12:- Can a DC motor be turned into a DC generator? What changes are required to be done?

Answer:- Yes, a DC motor can be turned into a DC generator.

In order to convert a DC motor into a DC generator, following changes are required to be made:-

i. The magnetic field must be provided by a permanent magnet instead of electromagnet.
ii. An arrangement must be provided to rotate the armature coil.

Question 15.13:- Is it possible to change both the area of the loop and the magnetic field passing through the loop and still not have an induced emf in the loop?

Answer:- Yes, if plane of the loop is always kept parallel to the direction of magnetic field, no emf will be induced in the loop either by changing its area or by changing magnetic field.

Question 15.14:- Can an electric motor be used to drive an electric generator with the output from the generator being used to operate the generator?

Answer:- No, it is not possible. If it is possible, it will be a self-operating system without getting any energy from some external source, which is against the law of conservation of energy.

Question 15.15:- A suspended magnet is oscillating freely in a horizontal plane. The oscillations are strongly damped when a metal plate is placed under the magnet. Explain why this occurs?

Answer:- When a suspended magnet oscillates freely in a horizontal plane, it produces change of magnetic flux through the metallic plate. Induced current is produced in the metallic plate which opposes the motion of magnet according to Lenz's law and oscillations of the magnet are damped heavily.

Question 15.16:- Four unmarked wires emerge from a transformer. What steps would you take to determine the turns ratio?

Answer:- By checking the continuity of the wires with the help of an ohmmeter, the wires are separated as primary and secondary coils. An alternating emf of known voltage V_P is applied across the primary coil, the output voltage V_S is measured across the secondary coil. The turns ratio is determined by using the relation $N_S/N_P = V_S/V_P$.

Question 15.17:- a) Can a step-up transformer increase the power level?

b) In a transformer, there is no transfer of charge from the primary to the secondary. How is, then the power transferred?

Answer:- a) No a step up transformer cannot increase the power level. In an ideal transformer, output power is equal to input power. In a practical transformer, output power is less than the input power. A step-up transformer only increases the voltage level.

b) The two coils are magnetically linked in a transformer. The change of magnetic flux in one coil produces an induced emf in the other coil. Power transfer takes place through change of magnetic flux.

Question 15.18:- When the primary of a transformer in connected to ac mains the current in it a) is very small if the secondary circuit is open, but b) increase when the secondary circuit is closed. Explain these facts.

Answer:- a) When the secondary circuit is open, output power is zero. Since input power is slightly greater than output power, hence a small amount of current is drawn by primary coil from ac mains.

b) When the secondary circuit is closed, the output power increases. To provide a large power at output, more amount of power is to be provided by primary coil by drawing a large current from ac mains.