SHORT QUESTIONS

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?

Ans. As we know that according to Faraday's law of electromagnetic induction.

"Induced emf in a circuit is directly proportional to the negative of rate of change of magnetic flux.

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

From this equation we see that induced emf depends on the rate of change of magnetic flux and induced emf does not depend upon the resistance of the circuit but induced current depends on the resistance because.

$$I = \frac{E}{R}$$

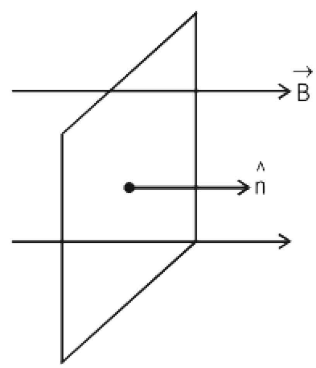
This shows that induced current is inversely proportional to resistance i.e., if resistance of conductor is less then current will be more and vice versa.

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 an emf induced in the loop? Give a reason for your answer?

Ans. There will be no induced emf produced in the loop because we know that according to Faraday's law of electromagnetic induction.

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

Here, $\frac{\Delta\phi}{\Delta t} = 0$



i.e., rate of change of magnetic flux is zero because normal of loop is oriented parallel to the magnetic field.

According to the relation

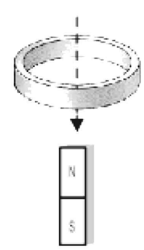
$$\varepsilon = -N\frac{\Delta\phi}{\Delta t}$$

$$\varepsilon = -N(0)$$

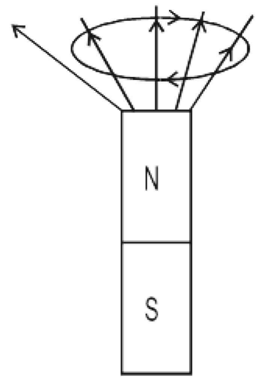
$$\varepsilon = 0$$

Hence no induced emf is produced.

15.3 A light metallic ring is released from above into a vertical bar magnet (figure). Viewed for above, does the current flow clockwise or anticlockwise in the ring?



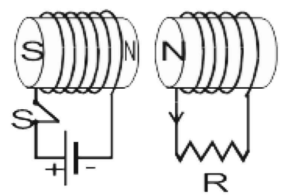
Ans. According to Lenz law the direction of induced current is opposite to the cause which produces it, therefore when the metallic ring is released from above into the bar magnet, the magnetic flux is changed in the ring and an induced emf is produced in it and hence North Pole is developed in the ring towards the north pole of the bar magnet. As view above, the current flows in clockwise direction.



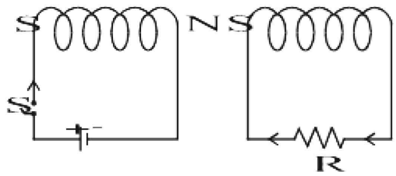
15.4 What is the direction of the current through resistor R in figure? As switch S is

(a) Closed (b) Opened

Ans. (a) When switch is closed, the current in the circuit increases from zero to maximum. During this interval, magnetic flux in the second coil increases from zero to maximum and an induced current is produced in it. The side of current carrying coil facing the other coil becomes North Pole so the current in the other coil must flow in anticlockwise direction shown.



(b) However when switch is opened, the current in the circuit decreases from maximum to zero and the flux links with other coil decrease and induced current is produced in reverse direction as shown in figure.

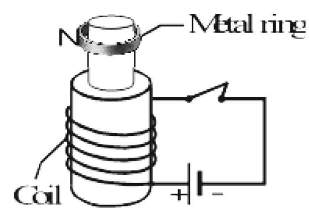


15.5 Does the induced emf always act to decrease the magnetic flux through a circuit?

Ans. No, because according to Lenz's law "the induced emf is always such as to oppose the cause which produces it" therefore if magnetic flux increases then induced emf will act in such a way to decrease the magnetic flux and if magnetic flux decreases then induced emf will act to increase the magnetic flux. So induced emf does not always act to decrease the magnetic flux.

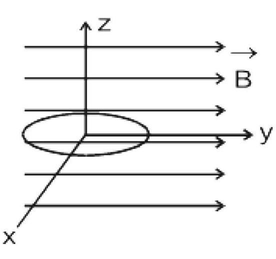
15.6 When the switch in the circuit is closed, a current is established in the coil and the metal ring jumps upward figure. Why? Describe what would happen to the ring if the battery polarity were reversed?

Ans. When the switch in the circuit is closed, the current is setup in the coil. Magnetic flux changes through the metallic ring and an induced emf is produced in it. The face of ring opposite to the coil develops similar poles of magnet and experiences repulsion from the side of coil and the ring jumps up. If the polarity of the battery is reversed then the ring will jump upward also.



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 co-ordinate axes should the coil be rotated in order to generate an emf and a current in the coil?

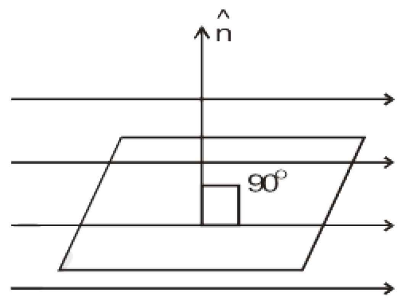
Ans. An emf and current in the coil is generated when it is rotated along x-axis. No change of flux takes place along y and z-axis because the coil is parallel to the magnetic field $\vec{B}$ all the time.



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?

Ans. If the plane of flat loop of wire is placed parallel to the magnetic field $\vec{B}$, then there is no flux changed through it and no emf is induced in the flat loop.

In this case, the angle between magnetic field $\vec{B}$ and vector area $\vec{A}$ is 90° therefore



$$\Delta\phi = \vec{B} \cdot \vec{A}$$
$$\Delta\phi = BA\cos\theta$$
$$\Delta\phi = BA\cos 90^\circ$$
$$\Delta\phi = BA(0)$$
$$\Delta\phi = 0$$

Since $\varepsilon = -N\dfrac{\Delta\phi}{\Delta t}$

$$\varepsilon = -N\frac{(0)}{\Delta t}$$
$$\varepsilon = 0$$

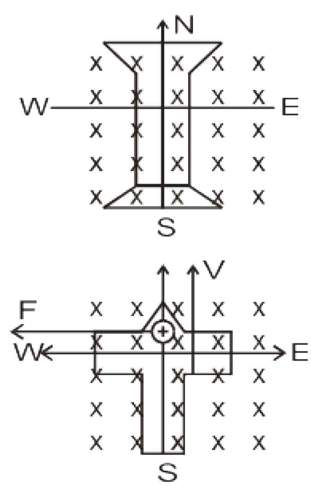
So no emf is induced in the flat loop of wire.

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?

Ans. As we know that the magnetic force on moving charge particle in uniform magnetic field is

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

The direction of this force can be found by right hand rue therefore when plane flies due north then according to right hand rule magnetic force will act towards west therefore its west wingtip become positive charge.



15.10 Show that ε and $\dfrac{\Delta\phi}{\Delta t}$ have same units.

Ans. As $\varepsilon = \dfrac{w}{q}$, ε weber/sec. where

$$\varepsilon = \frac{J}{C} = \text{Volt} \qquad \ldots\ldots \text{(i)}$$

$$e = \frac{\Delta\phi}{\Delta t} = \frac{\text{Weber}}{\text{Sec.}} = \frac{N \times m}{A \times \text{Sec.}}$$

But N.m = J and A × Sec. = C

Thus $\frac{\Delta\phi}{\Delta t} = \frac{\text{Weber}}{\text{Sec.}} = \frac{\text{N} \times \text{m}}{\text{A} \times \text{Sec.}} = \text{J/C}$ ...... (ii)

From eq. (i) and (ii)

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

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

Ans. Yes, when electric motor is running, its armature is rotating in a magnetic field. A torque acts on the armature and at the same time, magnetic flux is changing through the armature which produces an induced emf. But this emf is back emf.

15.12 Can a D.C motor be turned into a D.C generator? What changes are required to be done?

Ans. Yes, if battery from D.C motor is removed and connect these terminals to an external circuit. Now if the coil (armature) of the motor is rotated by some mechanical means, then D.C motor is converted into D.C generator.

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?

Ans. As we know that

$$\phi = BA \Rightarrow B = \frac{\phi}{A}$$

If ϕ remain constant

$$B = \frac{\text{Constant}}{A} \Rightarrow B \propto \frac{1}{A}$$

$$BA = \text{Constant}$$

If magnetic field B and vector area A are changed in such a way that the product BA remains constant then the change in flux is zero therefore

$$\Delta\phi = 0$$

Then according to Faraday's law

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

$$\varepsilon = -\frac{N(0)}{\Delta t}$$

$$\varepsilon = 0$$

Hence no emf is induced in the loop.

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

Ans. No, it is not possible because if it is possible then it will be a self-operating system without getting energy from some external source and this is against the law of conservation of energy.

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?

Ans. The oscillating magnet produce change of magnetic flux close to it. The metal plate placed under it experiences the change of magnetic flux. As a result an induced emf is produced in the metal plate due to the change in magnetic flux. According to Lenz law, induced current opposes its cause which are the oscillation of the magnet. So the oscillation of the magnet are strongly damped.

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

Ans. There are two steps for checking the four unknown wires.

(1) Separate two coils into primary and secondary coil by checking continuity of wires by using ohm-meter.

(2) Apply alternating voltage of known value V_p to one of the coil and the voltage across the other coil is measure by using voltmeter as V_s. Then by putting the values of V_p and V_s in

$$\frac{N_s}{N_p} = \frac{V_s}{V_n}$$

We can find the turn ratio. If the reading of voltmeter is less than input, then it is a step down transformer and if the reading of voltmeter is greater than input so it is a step up transformer.

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?

Ans. (a) No, a step up transformer does not increase power level.

As $P = VI$

Hence a step up transformer increases V by decreasing I and hence $P = VI$ remains constant, otherwise it will against law of conservation of energy.

(b) The two coils of the transformer are magnetically linked i.e., the change of flux through one coil is linked with other coil and induced emf is produced. Power is transferred due to magnetic flux linkage.

15.18 When the primary of a transformer is connected to A.C. 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.

Ans. (a) As for a transformer

$$\text{Input power} = \text{Output power}$$

$$V_pI_p = V_sI_s$$

When secondary circuit is open, then P_{out} (VI) = 0, so input power must be zero or very small. So input current I_p is very small in primary coil.

(b) However, when load is applied to secondary coil, greater power output is needed. Since output power = input power. So greater current is required in primary to equalize the power in the secondary coil.