ELECTROMAGNETIC INDUCTION

FARADAY'S LAW OF INDUCTION

Faraday's laws of electromagnetic induction

1. Faraday's First Law:

- When the magnetic flux passing through a closed loop experiences changes over time, or when a conducting wire intersects magnetic field lines, it results in the generation of an electromotive force (emf) within the loop or wire. This emf is termed "induced emf." if the circuit is closed, this induced emf causes the flow of electric current.

- The quantity of magnetic flux is defined as the product of the magnetic field and the area through which it passes.

2. FARADAY'S SECOND LAW:

- The magnitude of the induced emf is directly proportional to the rate of change of magnetic flux concerning time, specifically for a loop. For a wire, this magnitude is directly proportional to the speed at which the wire cuts across magnetic field lines.

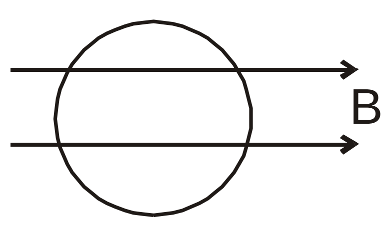
- A critical feature of the second law is that the negative sign signifies that the induced emf always opposes the change in magnetic flux.

- The standard unit of measurement for magnetic flux is the weber (wb).

In summary, faraday's laws of electromagnetic induction elucidate the following principles: when magnetic flux changes within a closed loop or when conducting wires traverse magnetic field lines, it generates an induced emf, and if the circuit is closed, it leads to the flow of electric current. The magnitude of this emf is directly related to the rate of change of magnetic flux with respect to time, with the negative sign indicating that it opposes the change in magnetic flux. Magnetic flux is quantified in webers.

Example.

Calculate the electromotive force (emf) induced in a coil when it is positioned within a uniform and unchanging magnetic field, with the magnetic field lines aligned parallel to the plane of the coil, as depicted in the diagram.



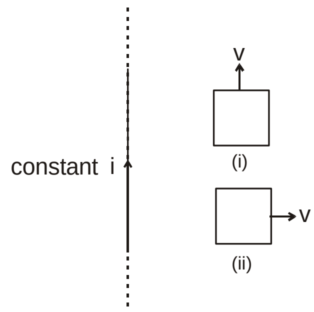
Solution.

$\phi = 0$ (always) since area is perpendicular to magnetic field.

$\therefore$ emf $= 0$

Example.

In the illustration provided, there is a lengthy wire carrying an electric current, along with two rectangular loops that are both in motion with a velocity denoted as 'v.' Determine the direction of the electric current within each of these loops.



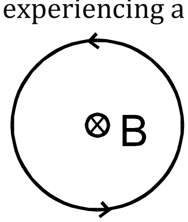
Solution.

In loop

(i) No emf will be induced because there is no flux change. In loop
(ii) emf will be induced because the coil is moving in a region of decreasing magnetic field inward in direction. Therefore, to oppose the flux decrease in inward direction, current will be induced such that its magnetic field will be inwards. For this direction of current should be clockwise.

Example.

Deduce the direction of the induced electric current within the coil presented in the diagram. It should be noted that the magnetic field is oriented perpendicular to the coil's plane, and this magnetic field is experiencing a progressive increase over time.



Solution.

Inward flux is increasing with time. To opposite it outward magnetic field should be induced. Hence current will flow anticlockwise