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EDDY CURRENTS

***Eddy currents are induced circulating currents produced in the body of a conductor due to change in magnetic flux linked with the conductor*. These currents were discovered by Foucault in the year 1895 and so they are also called Foucault currents. The direction of eddy currents is given by Lenz's law or Fleming's right hand rule.**

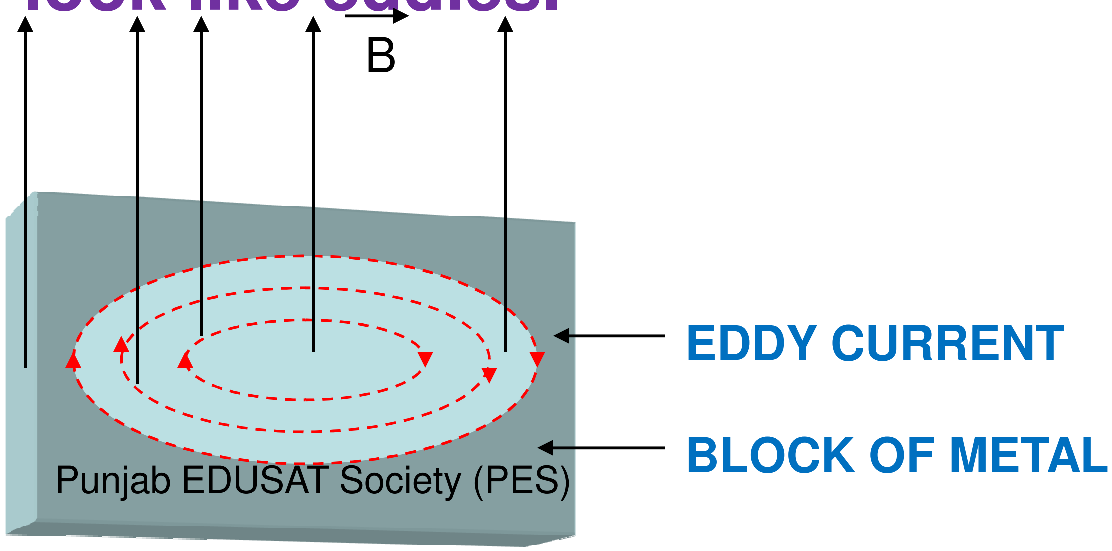
The magnitude of Eddy Current is

i = Induced e.m.f. / Resistance = e/R

$$e = -\, d\Phi/dt$$

$$i = -\,\frac{d\Phi/dt}{R}$$

When a block of metal is moved in or out of a magnetic field or placed in a non-uniform i.e., varying magnetic field, the amount of flux linked with block changes. Therefore, an induced e.m.f. is set up in the block. This induced e.m.f. causes currents to flow in concentric closed path throughout the body of the block in the same manner as in a closed loop placed in a varying magnetic field. Such currents are called eddy currents as they look like eddies.

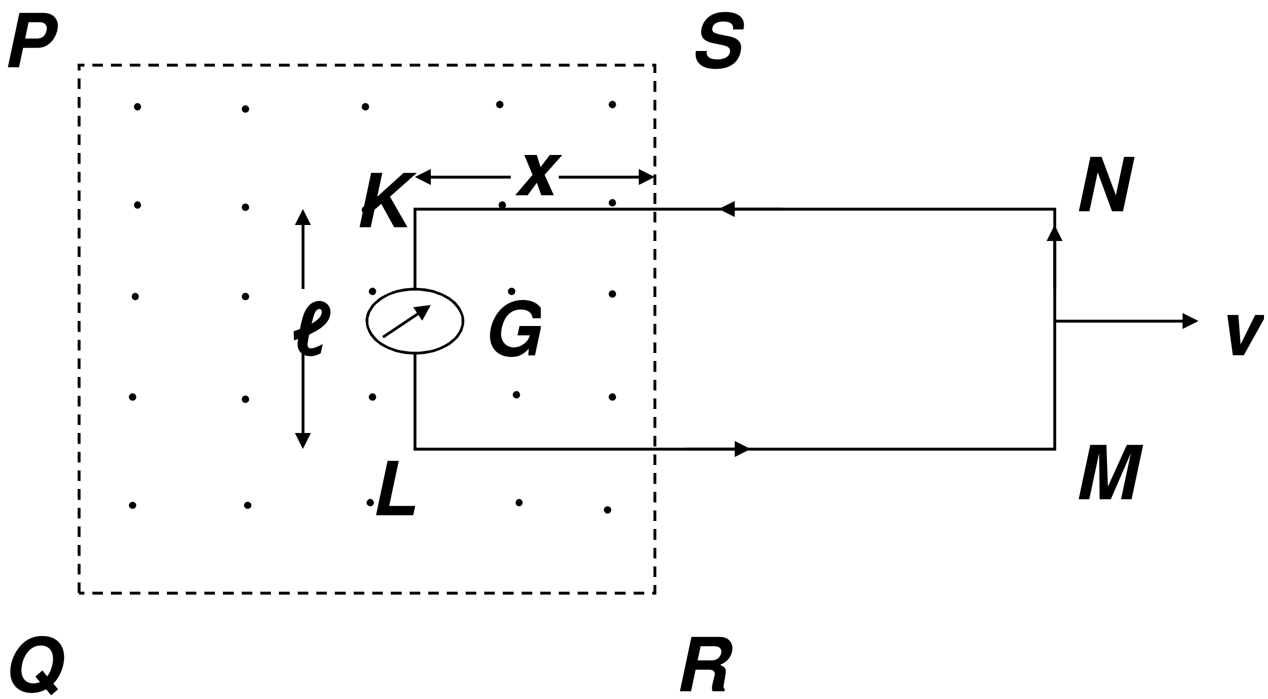


Various methods of producing induced e.m.f.

$\Phi = BA\cos\theta$, the magnetic flux can be changed by changing B, A or θ. Hence, there are three methods of producing induced e.m.f.

1. By changing the magnitude of the magnetic field B.
2. By changing the area A.
3. By changing the relative orientation of the surface area and the magnetic field (θ).

1. Induced e.m.f. by changing the magnetic field.
2. Induced e.m.f. by changing the area.



To calculate the induced e.m.f., suppose in a small time Δt, the loop is moved out of the magneic field through a small distance Δx.

Therefore, Decrease in the area of loop $= -\ell \, \Delta x$

Decrease in the magnetic flux linked with the loop, $d\Phi = -B\ell \, \Delta x$

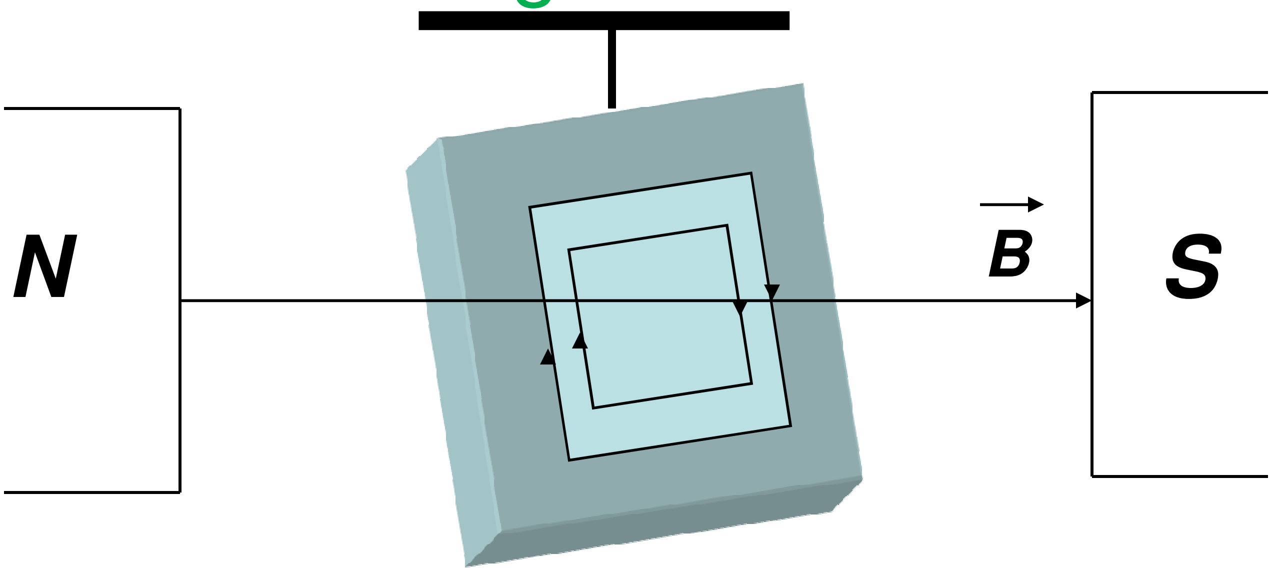
As induced e.m.f. $e = -d\Phi/dt$

$$e = +B\ell \, \Delta x / \Delta t \quad = B\ell v$$

3. When a coil is rotated in a magnetic field the angle between normal to the coil and the direction of the magnetic field changes, therefore, e.m.f. is induced in the coil. This is the basis of an a.c. generator.

Experiment to demonstrate Eddy Currents

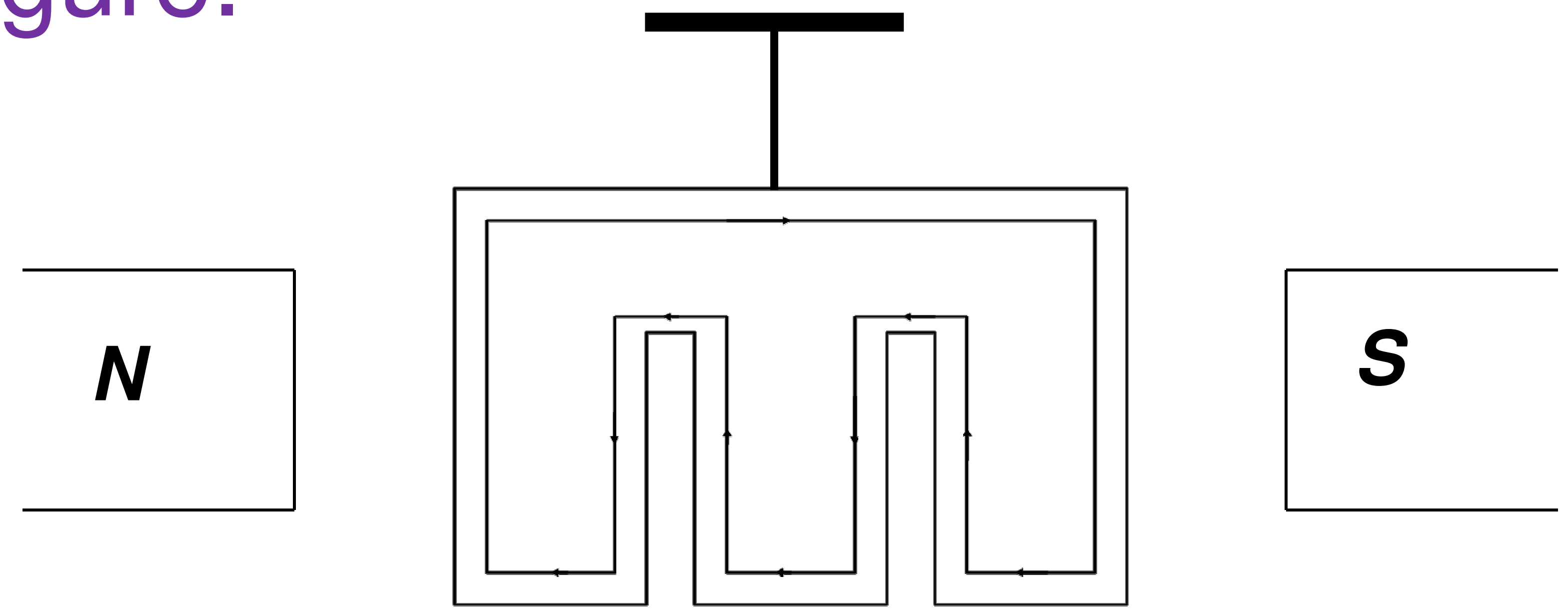
- If a rectangular metallic plate is suspended between the two poles of a magnet as shown in the figure.



- When magnetic field is not switched on the metallic plate once disturbed oscillates freely for a longer period but when the field is switched on the plate is allowed to oscillate about the same axis of rotation the oscillations are damped and in a little while plate comes to halt. This is because Eddy Currents are developed. As the plate enters in the field Eddy Currents are anti-clockwise according to Lenz's law and cause the repulsion of the plate away from the magnet.

- Similarly when plate leaves the field the currents are setup in the clockwise direction so as to oppose the movement of the plate out of the region of magnetic field. In either case the effect is to produce damping. If some narrow slots are cut across one end of the plate the plate is again made to oscillate in the magnetic field the damping effect is there but it is very less as compared to that in former case and plate is found to swing for a much longer time. It means Eddy Currents are reduced.

The **reason** is that for a closed loop of a given area in the plate along which induced current flows have much longer paths as shown in the figure.



Undesirable effects of Eddy Currents

- As the resistance of metallic conductors is small so the magnitude of Eddy Currents is large. Metal gets heated to a high temperature, this leads to the loss of electrical energy in form of heat.
- The excessive heat produced to Eddy Currents may break the insulation in electrical appliances like coils of dynamos and electric motors thus reduce their life.

- **Eddy Currents cause damping effects and thus they oppose the relative motions.**

To minimize the losses due to Eddy Currents

The solid metallic core of the device is built by large number of thin sheets separated by an insulating material like lacquer. Such a core is called *laminated core.* Such laminated cores are often used in transformers, generators and motors.

Applications of Eddy Currents

- Working of induction furnace is based on the heating effects of Eddy Currents.
- Induction motors
- In dead-beat Galvanometers
- In Electromagnetic brakes
- In speedometers
- Indectothermy
- Energy meters
- Electromagnetic shielding