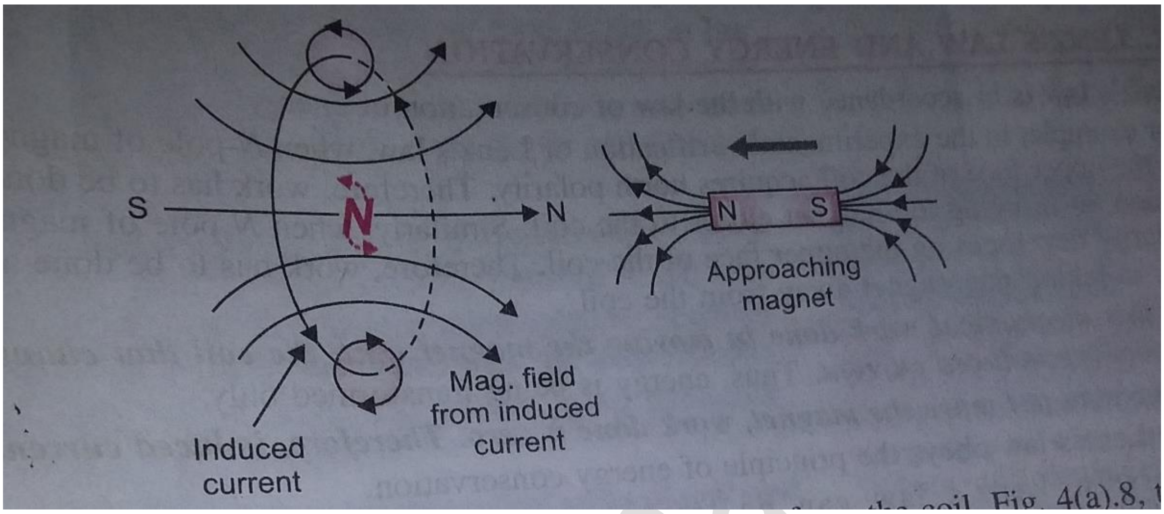
# <u>Lenz's law</u>

Lenz's law of electromagnetic induction states that the direction of the current induced in a conductor by a changing magnetic field (as per Faraday's law of electromagnetic induction) is such that the magnetic field created by the induced current opposes the initial changing magnetic field which produced it. The direction of this current flow is given by Fleming's right hand rule.




Lenz's law is based on Faraday's law of induction. Faraday's law tells us that a changing magnetic field will induce a current in a conductor. Lenzs law tells us the direction of this induced current, which opposes the initial changing magnetic field which produced it. This is signified in the formula for Faraday's law by the negative sign ('–').

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

Where:

$\varepsilon$ = Induced emf

$\delta\Phi_B$ = change in magnetic flux

N = No of turns in coil

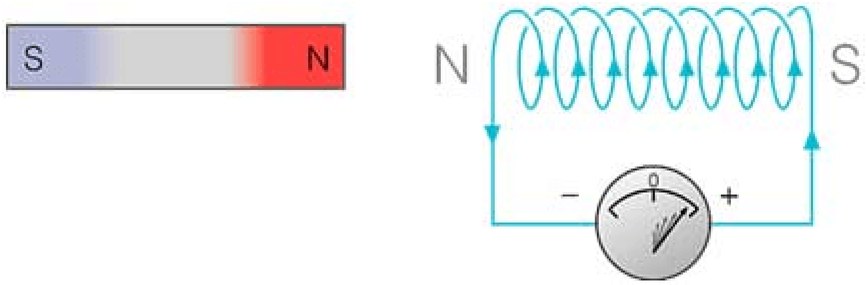
**<u>Lenz's Law and Conservation of Energy</u>**

To obey the conservation of energy, the direction of the current induced via Lenz's law must create a magnetic field that opposes the magnetic field that created it. In fact, Lenz's law is a consequence of the law of conservation of energy.

Lenz's Law Explained

To better understand Lenz's law, let us consider two cases:

**Case 1: When a magnet is moving towards the coil.**

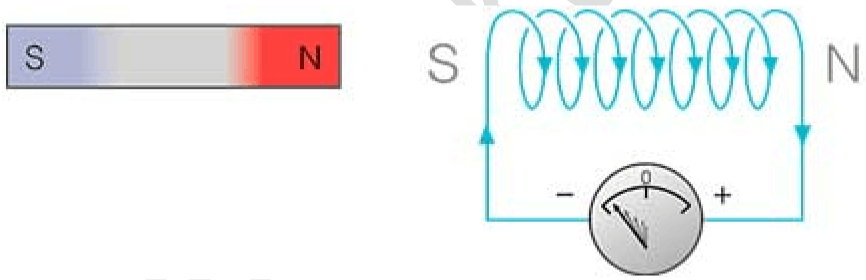



What is Lenz Law

When the north pole of the magnet is approaching towards the coil, the magnetic flux linking to the coil increases. According to Faraday's law of electromagnetic induction, when there is a change in flux, an EMF and hence current is induced in the coil and this current will create its own magnetic field.

Now according to Lenz's law, this magnetic field created will oppose its own or we can say opposes the increase in flux through the coil and this is possible only if approaching coil side attains north polarity, as we know similar poles repel each other. Once we know the magnetic polarity of the coil side, we can easily determine the direction of the induced current by applying right hand rule. In this case, the current flows in the anticlockwise direction.

**Case 2: When a magnet is moving away from the coil**




When the north pole of the magnet is moving away from the coil, the magnetic flux linking to the coil decreases. According to Faraday's law of electromagnetic induction, an EMF and hence current is induced in the coil and this current will create its own magnetic field.

Now according to Lenz's law, this magnetic field created will oppose its own or we can say opposes the decrease in flux through the coil and this is possible only if approaching coil side attains south polarity, as we know dissimilar poles attract each other. Once we know the magnetic polarity of the coil side, we can easily determine the direction of the induced current by applying right hand rule. In this case, the current flows in a clockwise direction.

**Eddy current:**

An eddy current is a current set up in a conductor in response to a changing magnetic field. They flow in closed loops in a plane perpendicular to the magnetic field. By Lenz law, the current swirls in such a way as to create a magnetic field opposing the change; for this to occur in a conductor, electrons swirl in a plane perpendicular to the magnetic field.

## Some Practical Applications

### 1.Electromagnetic damping

Used to design deadbeat galvanometers. Usually, the needle oscillates a little about its equilibrium position before it comes to rest. This causes a delay in taking the reading so to avoid this delay, the coil is wound over a non-magnetic metallic frame. As the coil is deflected, eddy currents set up in the metallic frame and thus, the needle comes to rest almost instantly.

### 2. Induction Furnace

In rapidly changing magnetic fields, due to a large emf produced, large eddy currents are set up. Eddy currents produce temperature. Thus a large temperature is created. So a coil is wound over a constituent metal which is placed in a field of the highly oscillating magnetic field produced by high frequency. The temperature produced is enough to melt the metal. This is used to extract metals from ores. Induction furnace can be used to prepare alloys, by melting the metals at a very high temperature.

### 3. Magnetic breaking in electronic train

During braking, the brakes expose the metal wheels to a magnetic field which generates eddy currents in the wheels. The magnetic interaction between the applied field and the eddy currents acts to slow the wheels down. The faster the wheels spin, the stronger is the effect, meaning that as the train slows the braking force is reduces, producing a smooth stopping motion.