

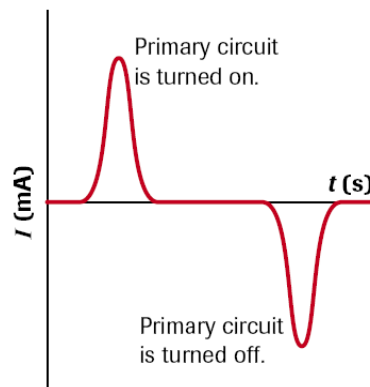
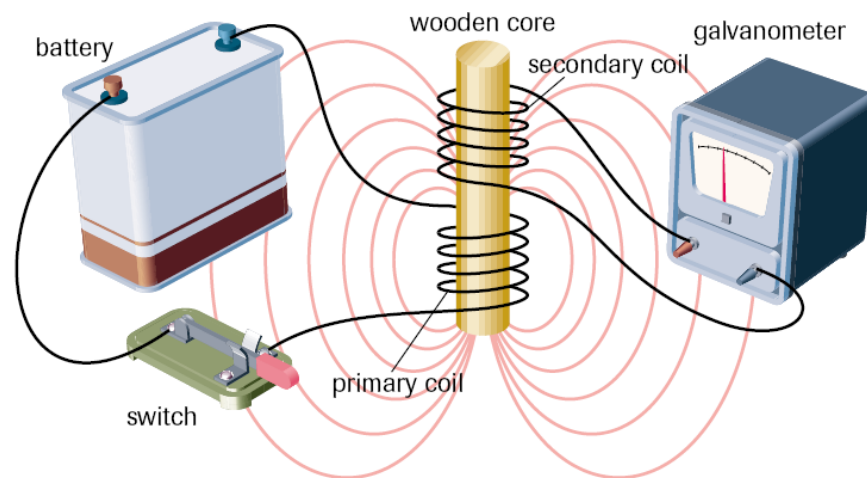
## 8.5 Electromagnetic Induction

### Physics Tool box

- The law of electromagnetic induction states that an electric current is induced in a conductor whenever the magnetic field in the region of the conductor changes.
- The greater the change in the magnetic field per unit time, the larger the induced current.
- Lenz's law states that when a changing magnetic field induces a current in a conductor, the electric current is in such a direction that its own magnetic field opposes the change that produces it.

Almost every modern device from computer to cars have electric circuits at its heart. They know that an electromotive force (emf) is required for the current to flow. For the vast majority of our home devices the source of the "emf" is a electric generating station. The station creates electrical energy by converting other forms of energy into electrical. The technique that the stations uses is by a process called electromagnetic induction.

Faraday discovered induction by wrapping a coil around a wooden core, but also discovered that the induced current was short lived even though the primary current was still there. And when the primary current was turned off, the induced reappeared, but in the opposite direction.



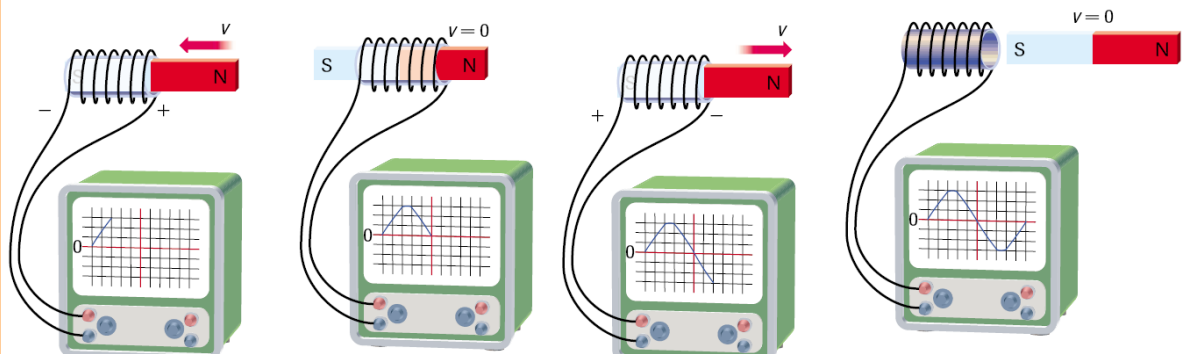
How were current to be explained?

Faraday experimented with devices to induce current and finally combined all his observations to come up with the law of electromagnetic induction.

### Law of Electromagnetic Induction.

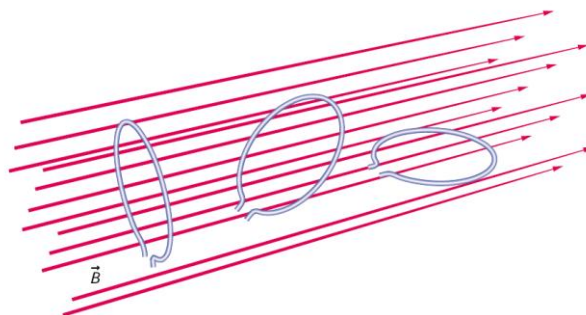
An electric current is induced in a conductor whenever the magnetic field in the region of the conductor changes in time.

Faraday's law of induction can be demonstrated by plunging a bar magnet into a solenoid connected to a galvanometer (configured as an ammeter) or oscilloscope. The oscilloscope indicates the potential difference in the secondary coil.



It demonstrates that the current is produced by a changing magnetic field and the greater the change, the larger the induced current.

Currents can also be produced in a loop of wire rotating in a uniform magnetic field. The magnetic field through the loop is changing the most when the loop is perpendicular to the field (raising the current to the maximum) and not changing when it is parallel (the current drops to zero for an instant). This is the principle used by electricity generators.



The next question one wants to ask, "What determines the direction of the induced current?". Heinrich Lenz, using the law of conservation of energy, discovered the answer.

Lenz reasoned that when the field from a moving bar magnet induces a current in a solenoid, this current gives rise to another magnetic field (the "induced" field).

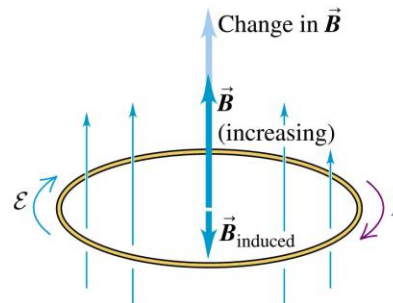
### Lenz's Law

When a current is induced in a coil by a changing magnetic field, the electric current is in such a direction that its own magnetic field opposes the change that produced it.

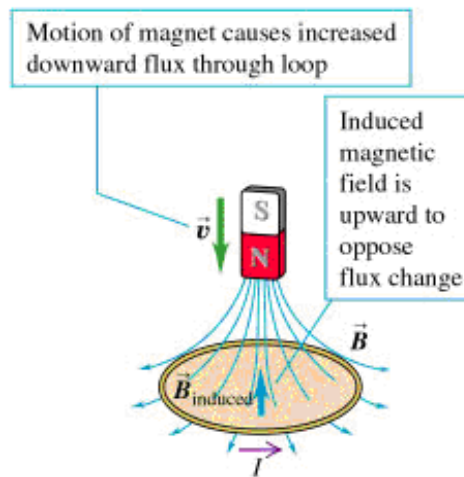
The total energy will remain constant since the energy lost by the magnet due to the induced field is equal to the energy gained by yhr current due to the inducing field.

### Example

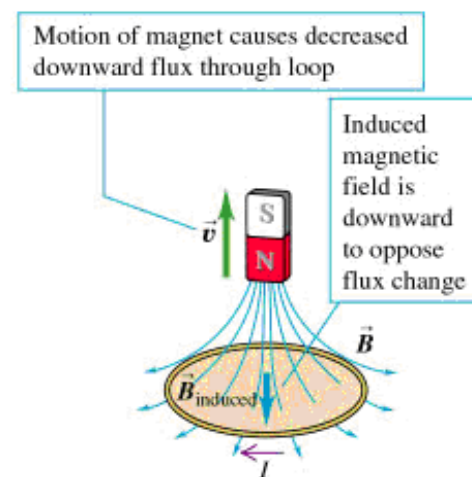
In the diagram below, there is a uniform magnetic field  $\vec{B}$  through the coil. The magnitude of the field is increasing, and the resulting induced emf causes an induced current. Use Lenz's law to determine the direct of the induced current.



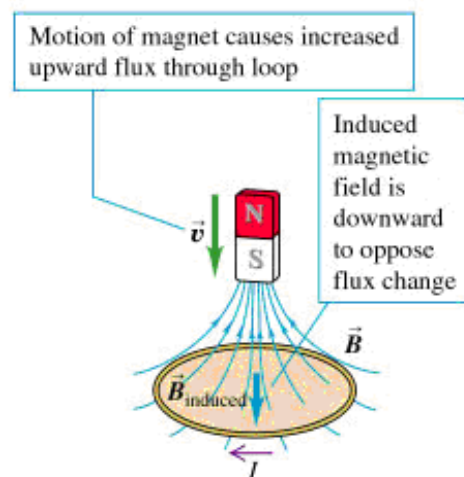
### Solution:



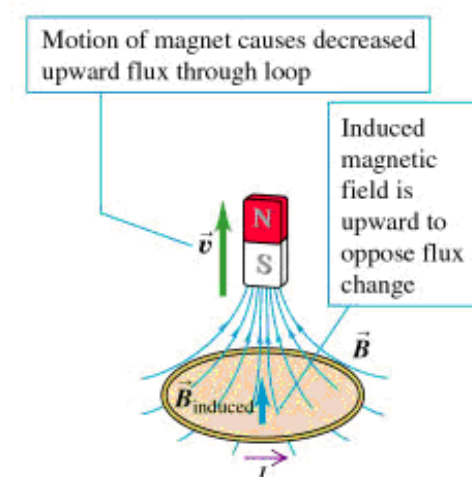
(a) To produce this induced field, induced current must be *counterclockwise* as seen from above loop



(b) To produce this induced field, induced current must be *clockwise* as seen from above loop



(c) To produce this induced field, induced current must be *clockwise* as seen from above loop



(d) To produce this induced field, induced current must be *counterclockwise* as seen from above loop