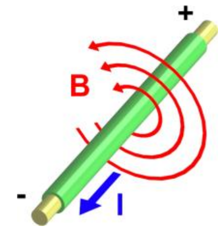
Electromagnetic Induction

(Creating current)



IN our previous discussion of magnetism we learned that:

A steady electrical current could create a magnetic field.

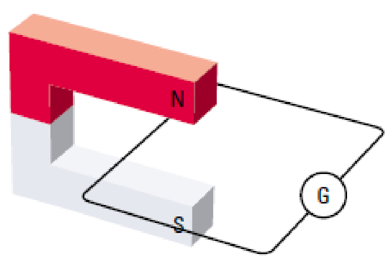
Once this was discovered, scientists then tried to:

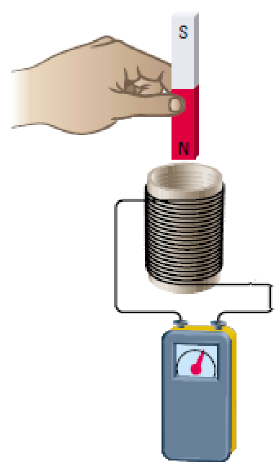
use a **magnetic field to *generate* a Current.**

Faraday's Law of Electromagnetic Induction

A scientist named Micheal Faraday explored how to use magnets to generate an electrical current through a wire. He quickly discovered that if you

Moving a magnetic field near a wire (or moving a wire near a magnetic field) you will generate a current in the wire



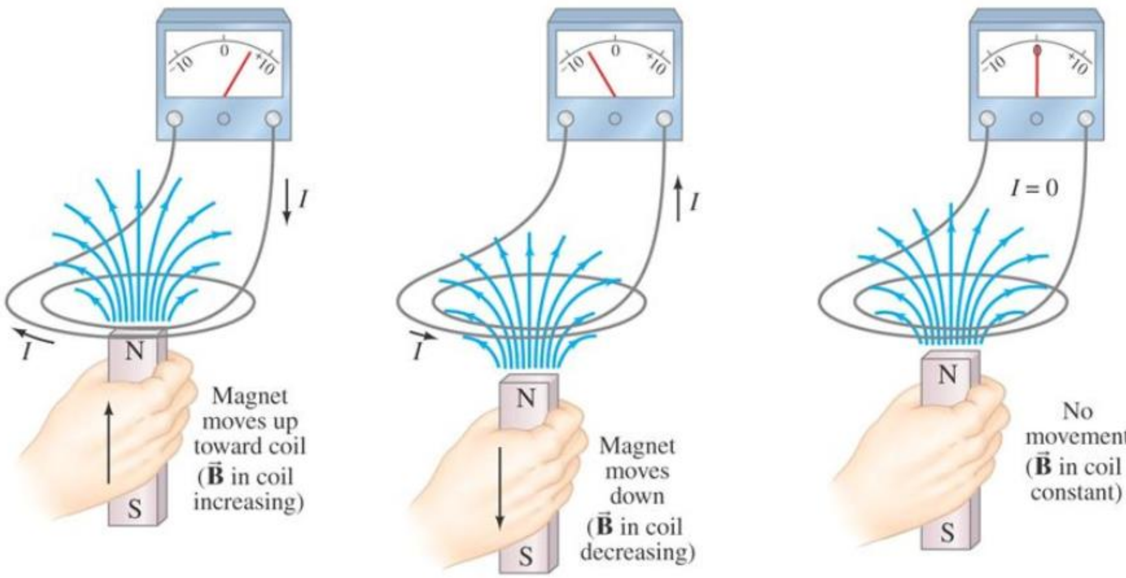


Key to his discovery was that **you needed to move the magnetic field** relative to the wire to generate current. If the wire was exposed to a **changing** magnetic field, current would flow through it.

Faraday summarized his finding in a profound and amazing new law now known as the **law of electromagnetic induction**.

Law of Electromagnetic Induction

An electric current is induced in a conductor when it is in the presence of a **changing** magnetic field



By observing what happens when a bar magnet is plunged into the core of a coil that is connected to a voltmeter, it is possible to conclude that the factors affecting the magnitude of the induced current are:

- the **number of turns** on the induction coil
- the **rate of change of the magnetic field**
- the **strength of the magnetic field**

Faraday's Law of Induction Formula:

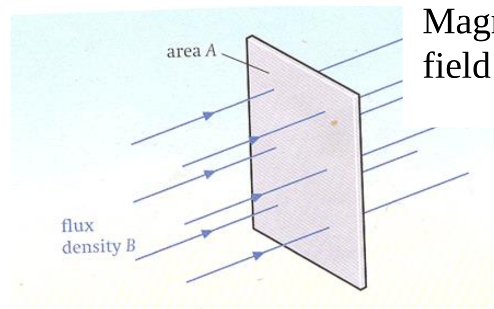
$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$$

Voltage

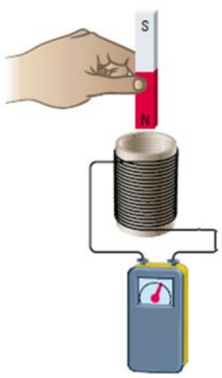
Magnetic field

$$\text{Magnetic flux} = \Phi = B\,A$$

Area perpendicular to magnetic field B



Magnetic field - **B**



Faraday's Law

$$\text{Voltage} = -N\frac{\Delta\Phi}{\Delta t}$$

Lenz's Law

where N = number of turns
Φ = BA = magnetic flux
B = external magnetic field
A = area of coil

$\mathcal{E}$ = Voltage

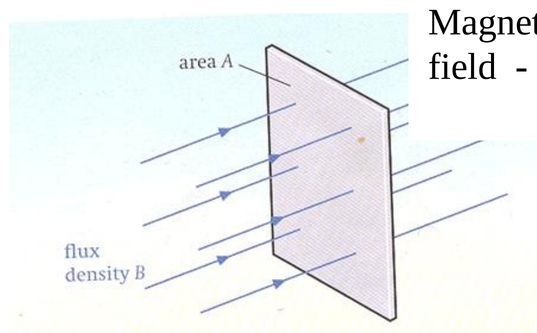
The Voltage you generate depends on **N** (number of coils)

and **how fast** you **change** the **magnetic field** (flux) near the coils.

Magnetic field

$$\text{Magnetic flux} = \Phi = B\,A$$

Area perpendicular to magnetic field B



Magnetic field - **B**

Moving Conductors.

Another way to induce a current or voltage in a conductor is to move a conductor through a magnetic field. As shown below.

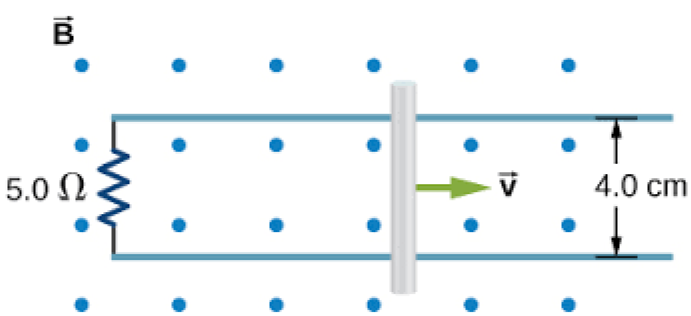
The EMF (voltage that gets produced) relates to:

1. How fast the conductor is being moved
2. the length of the conductor
3. the strength of the magnetic field

For these situations we can apply the following simple formula:

$$\mathcal{E} = vBL$$

$\mathcal{E} =$ motional emf (V)
$v =$ speed of conductor (m/s)
$B =$ magnetic field magnitude (T)
$L =$ length of conductor (m) [1]

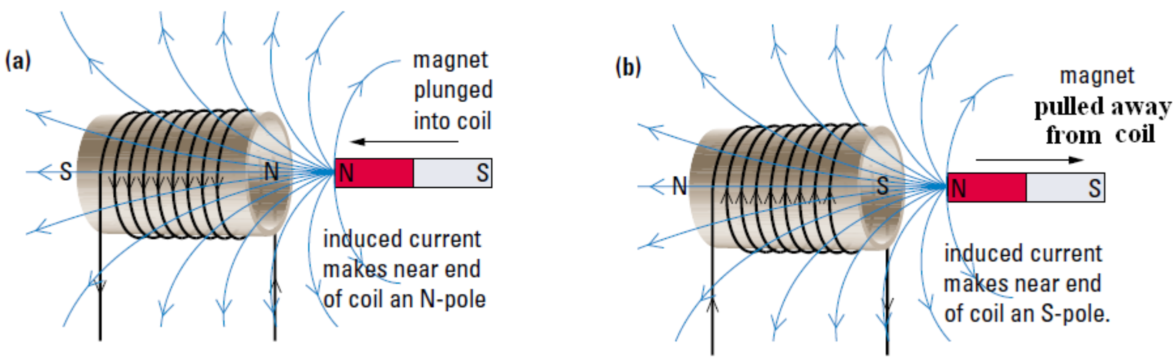


What determines the direction of the induced current?

Lenz's Law

When the North-pole of a bar magnet moves towards a coil, a current (that get created) travels in a *direction* so that the newly created magnetic field's North pole is created where it will *oppose the motion of the magnet.*

You must do work to create electrical current

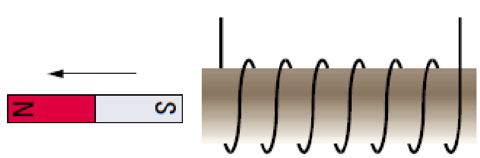


Lenz's Law is really an application of the Law of Conservation of Energy. It wouldn't make sense that, when you induce a current by moving a magnet, the new magnet field created by the current would "assits" the initial motion.

We have to do work (push against something) to create current.

> **Lenz's Law**
> For a current 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.

Example 1) Determine the direction of the electric current for the case in **Figure below.**



Example 2) Determine the pole of the bar magnet that is being inserted into the induction coil in **Figure**.