Electromagnetism

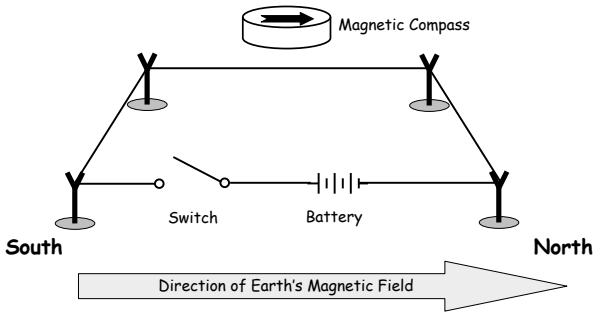
In this lecture

- ★Electromagnetic Effect
- ★Electromagnets
- ★Electromagnetic Induction
- ★Electromechanical Devices
- ★Transformers

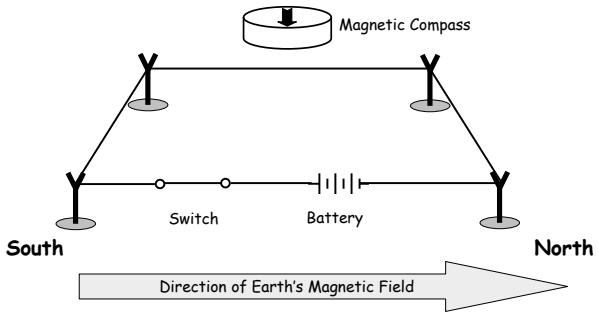
Electromagnetic Effect

Electricity & magnetism are different aspects of the same basic phenomenon: '*Electromagnetism*'

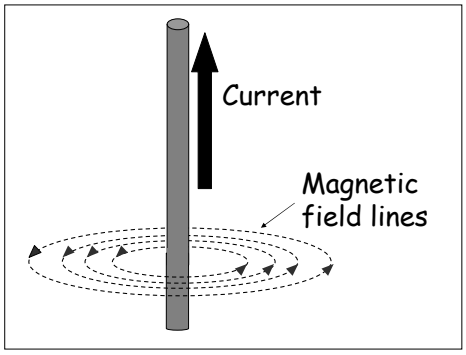
Oersted's Experiment



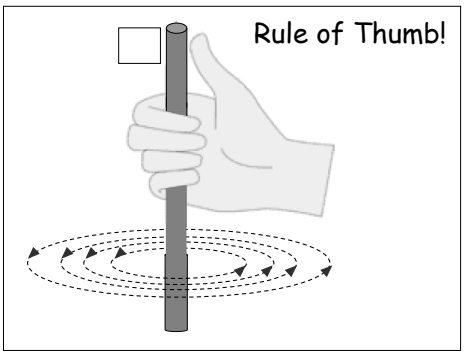
Oersted's Experiment



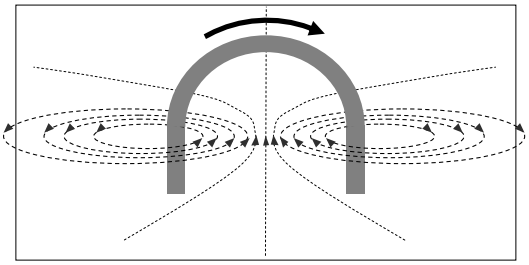
Current Carrying Wire



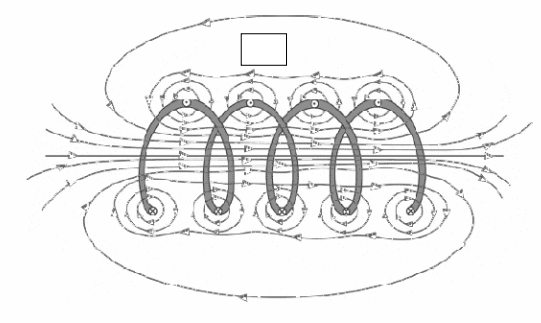
Current Carrying Wire



Solenoid

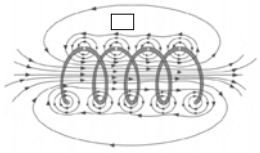


Solenoid



Magnetic Field Inside Solenoid

Magnetic Field at the centre of a long solenoid

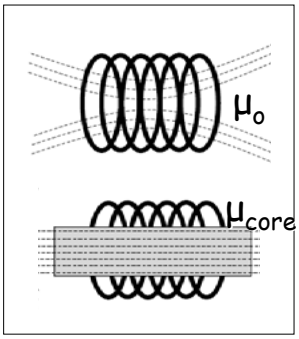


$$B=\mu_o n I$$

- n = turns per unit length
- I = current in wire
- μ_o = magnetic permeability of free space

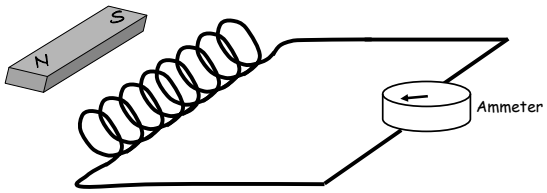
Electromagnet

- Iron core wrapped in wire coil
- Iron core has a greater magnetic permeability than air and therefore intensifies field into coil

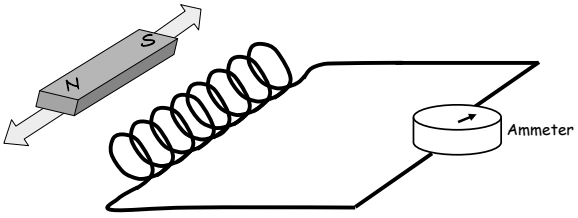


$$B = \mu_{core} n I$$

Electromagnetic Induction



Electromagnetic Induction



- *Faraday's Law:* An electric current is induced to flow in a circuit if some part of the circuit is in a changing magnetic field

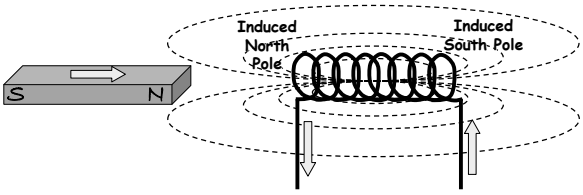
Electromagnetic Induction

Magnitude of induced current is governed by the following:

1. Strength of Magnetic Field
2. Rate of change of Magnetic Field
3. Angle of conductor to Magnetic Field
4. Number of turns in conductor

Electromagnetic Induction

Lenz's Law: The induced current flows in a direction such that it opposes the action that induces it.



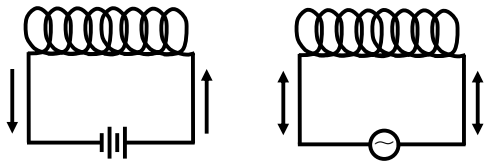
Electromagnetic Induction

Electromagnetic Laws govern the induction of currents by changing magnetic fields.

There are two basic types of induction:

1. Self induction
2. Mutual induction

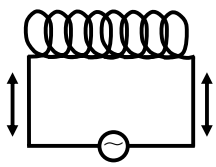
Self Induction



- DC current flow relatively unimpeded
- AC current is impeded due to self induction

Self Induction

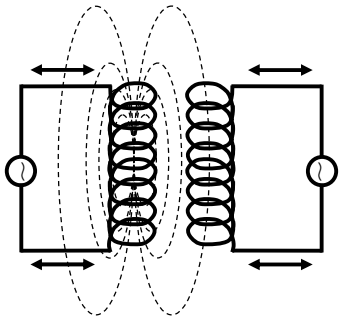
- AC current – alternating magnetic field
- According to Lenz an opposing action will be setup in the coil
- Induced voltage that opposes the source voltage ξ
- L is inductance



$$\xi = L\frac{di}{dt}$$

Mutual Induction

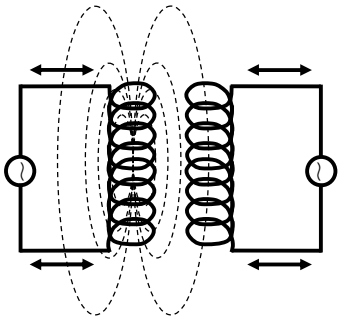
- AC current in coil produces alternating magnetic field
- Alternating magnetic field induced alternating current in second coil



Mutual Induction

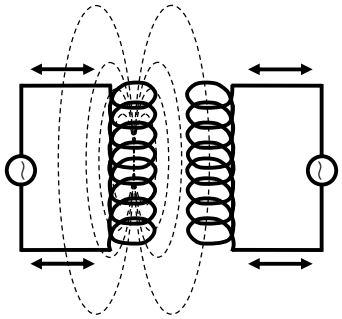
First coil is called the *Primary Coil*

Coil in which current is induced is called he *Secondary coil*



Mutual Induction

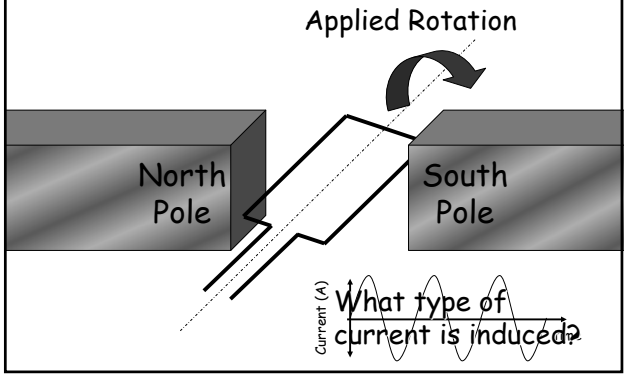
Mutual induction is the generation of an alternating current in a secondary coil by supplying an alternating current to the primary coil



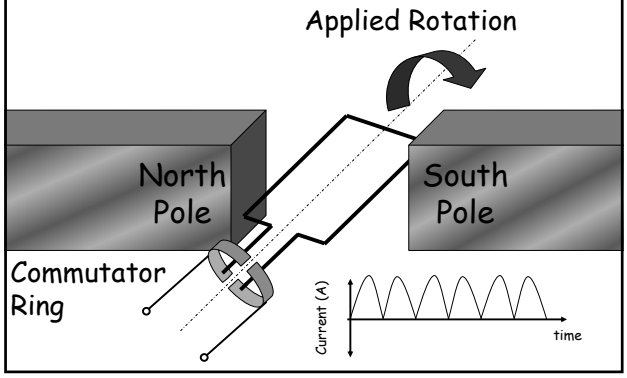
Electromechanical Devices

- Electric Generators & Motors are applications of Oersted's & Faradays's experiments

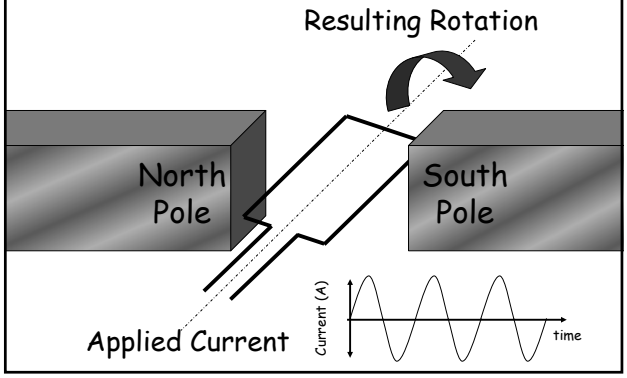
Electric Generator



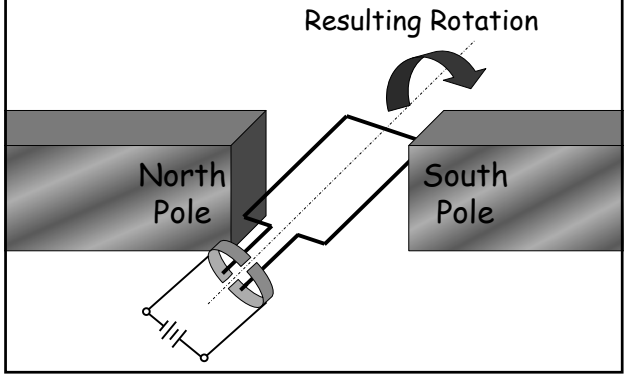
Electric Generator



Electric Motor

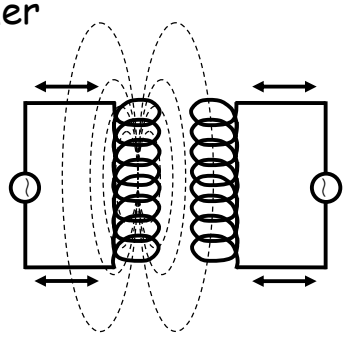


Electric Motor



Transformer

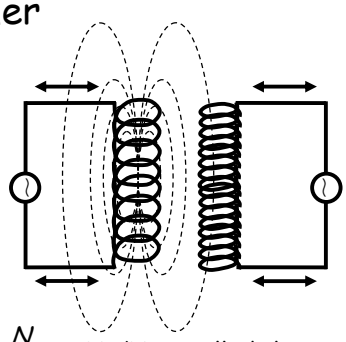
- Mutual induction
- Current is proportional to magnetic field and inversely proportional to the number of turns



Transformer

Example

The Secondary coil has twice as many turns as the primary coil



$\frac{V_s}{V_p} = \frac{N_s}{N_p}$ *and* $\frac{I_p}{I_s} = \frac{N_s}{N_p}$

N_S/N_P is called the *turn ratio* of a transformer

Example

- The turns ratio of a transformer is 0.1.
- What is the current in the secondary coil if the current flowing in the primary coil is 1 A?

Summary

★Electromagnetic Effect
★Electromagnets
★Electromagnetic Induction
★Electromechanical Devices
★Transformers

Practice Questions

1. State the two principle laws of electromagnetism
2. There are 125 turns on the primary side, N_p, of a transformer and 90,000 turns on the secondary side, N_s. If 110 V (ac) is supplied to the primary winding, V_p, what will the voltage induced in the secondary winding, V_s?
3. Describe the process of mutual induction
4. Why is it necessary to use a commutator ring in a DC motor?
5. Why is an iron core generally used in an electromagnet?