

**X PHYSICS SHORT NOTES**

# 10. Electromagnetism

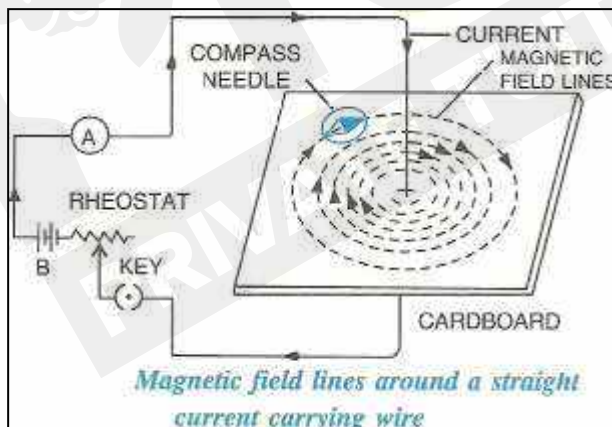
## A) MAGNETIC EFFECT OF ELECTRIC CURRENT

➤ **Magnetic effect of electric current:**

- **Discoverer:** Han Oersted, 1820.
- **Procedure:** Arrange the battery, wire and compass needle as shown in the diagram.
- **Conclusion:**
  - A current produces a magnetic field around it, called the magnetic effect of the current.
  - The strength and direction of the magnetic field depends on the magnitude and direction of the current.

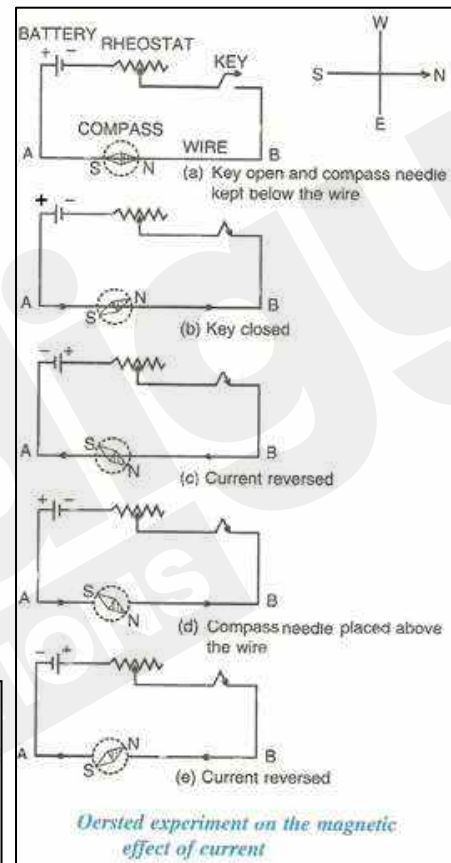
➤ **Magnetic field and field lines due to current in a straight wire:**

- **Experiment:**



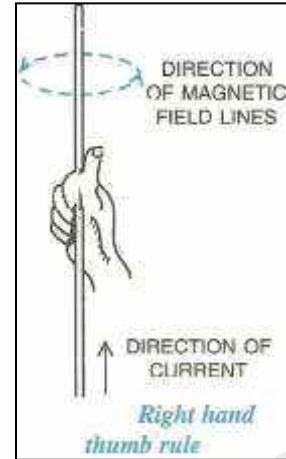
- **Conclusion:**

- A current carrying conductor produces a magnetic field around it.
- The strength and direction of the magnetic field formed depends on the strength and direction of the current flowing in the conductor.



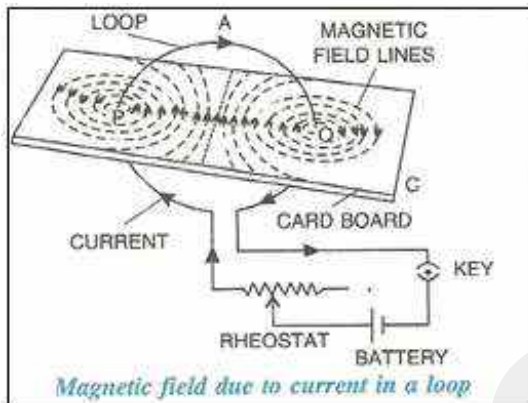
➤ **Rule to find the direction of magnetic field:**

- **Right hand thumb rule:** It is the rule that governs the direction of magnetic field by a current carrying conductor such that on holding the wire, the thumb points in the direction of flow of current, and the magnetic field lines are indicated by the direction of fingers encircling it.



➤ **Magnetic field due to current in a loop (or circular coil):**

○ **Experiment:**

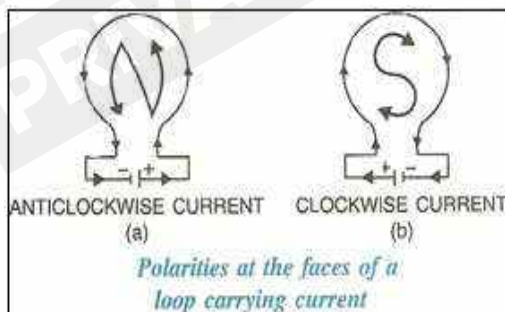


○ **Conclusion:**

- A current carrying loop produces a magnetic field around both its point.
- The strength and direction of the magnetic field formed depends on the strength and direction of the current flowing in the loop.
- The polarity acquired at the two faces of the loop depends on the direction of the current and is determined by clock rule.

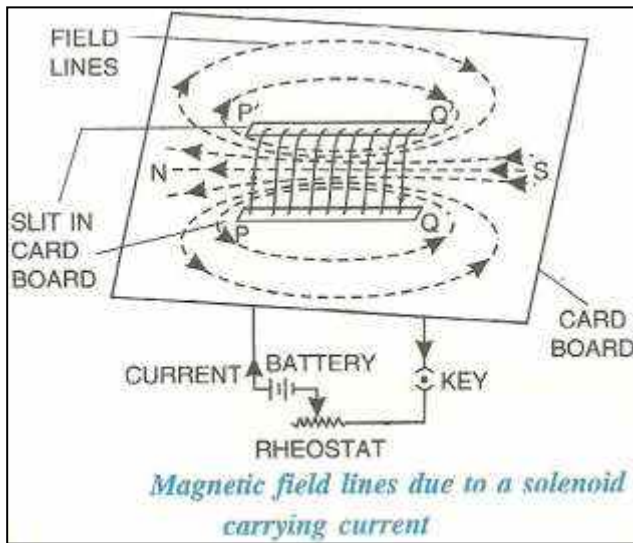
○ **Clock rule to determine the direction of the magnetic field:**

- **General rule:** Clockwise current-south pole and anticlockwise current-north pole.



➤ **Magnetic field due to a current carrying cylindrical coil (or solenoid):**

- **Solenoid:** Solenoid is a cylindrical coil formed by winding a conducting wire, having length of the coil greater than the diameter of the cylinder.

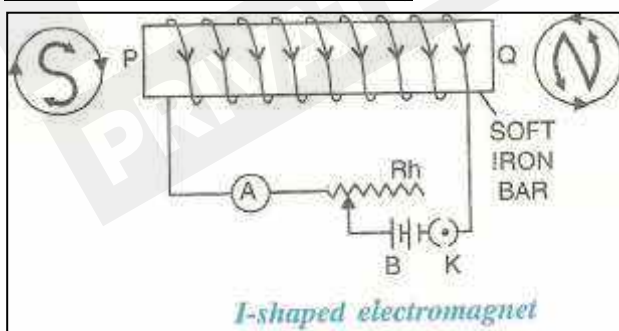


○ **Conclusion:**

- A current carrying solenoid produces a magnetic field around both its ends.
- The strength and direction of the magnetic field formed depends on the strength and direction of the current flowing in the solenoid.
- The polarity acquired at the two faces of the solenoid depends on the direction of the current and is determined by clock rule.
- A soft iron core can be used to increase the strength of the magnetic field

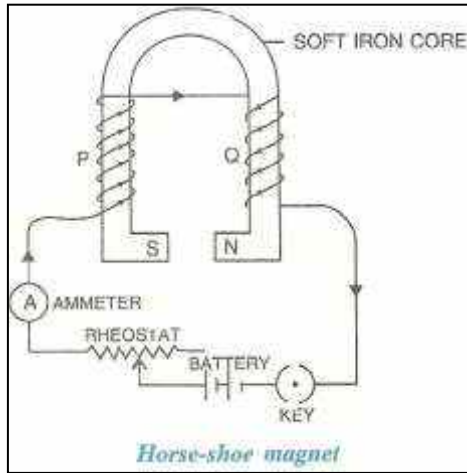
➤ **Electromagnet:**

- **Definition:** An electromagnet is an artificial, temporary, strong magnet made by passing electric current in the coil wound around a soft iron core.
- **I – shaped (bar) electromagnet:**



- **Use:** In Relay (a switching device).

- **U – shaped (horse-shoe) electromagnet:**



- **Use:** D.C. motor, A.C. generator, etc.

- **Factors affecting magnetic field of an electromagnet:**

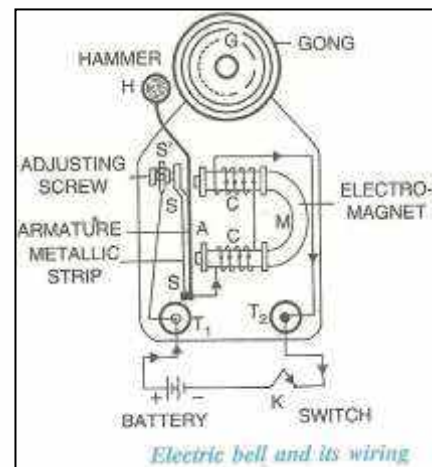
- No. of turns in a solenoid – **Directly Proportional.**
- Current flowing in a solenoid – **Directly Proportional.**

- **Difference between electromagnet and a permanent magnet:**

Electromagnet	Permanent magnet
The polarity can be reversed.	The polarity cannot be reversed.
It produces a temporary magnetic field.	It produces a permanent magnetic field.
It can easily be demagnetized by switching off the current.	It cannot be easily demagnetized.
It is made of soft iron.	It is made of steel.
The magnetic field strength can be changed.	The magnetic field strength cannot be changed.
The magnetic field is very strong.	The magnetic field is not very strong.

- **Electric bell:**

- **Definition:** An electric bell is a device which converts electrical energy to sound energy with the help of an electromagnet.
- **Principle:** It works due to the magnetic effect produced by the current.

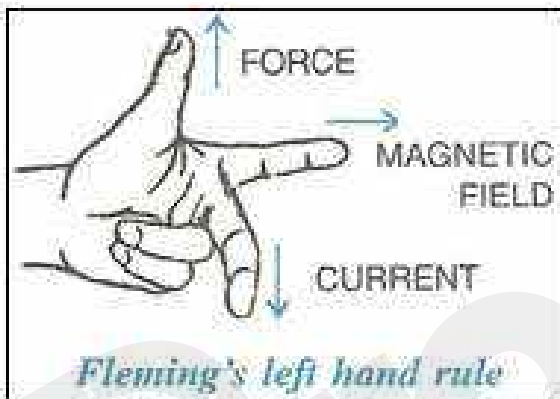


## B) FORCE ON A CURRENT CARRYING CONDUCTOR IN A MAGNETIC FIELD AND ITS APPLICATION IN D.C. MOTOR.

### ➤ Force on a current carrying conductor in a magnetic field:

- **Lorentz force:** It is a force experienced when a charge moves (current passed) in a magnetic field, in a direction other than the direction of the magnetic field.
- **Principle:** A conductor carrying current experiences Lorentz force just as a moving charge (current) placed in a magnetic field, in a direction other than the direction of the magnetic field.

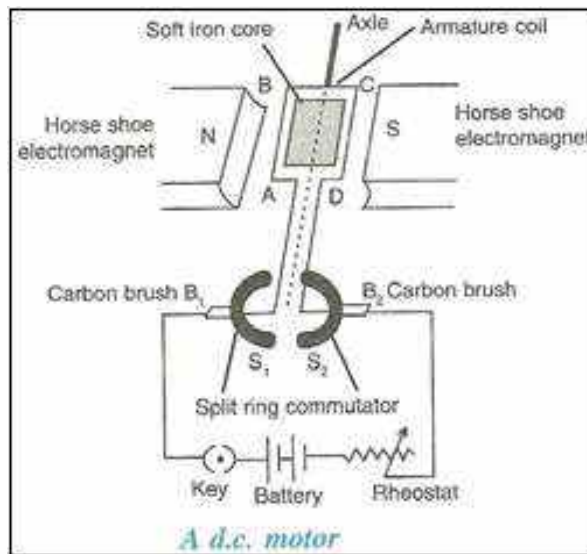
### ➤ Fleming's left hand rule for the direction of force:



- It is the rule that governs the direction of force on a current carrying conductor, where the left hand forefinger indicates the direction of magnetic field, the central finger indicates the direction of current and the thumb indicates the direction of force of conductor (motion direction).

### ➤ Simple D.C. motor/Electric motor:

- **Definition:** A simple electric D. C. motor is a device that converts electrical energy into the mechanical energy.
- **Principle:**
  - An electric current passed in a conductor placed normally in a magnetic field, experiences a force due to which the conductor begins to move and mechanical energy (work) is obtained. The Fleming's left-hand rule is used to obtain the direction of force on the conductor.



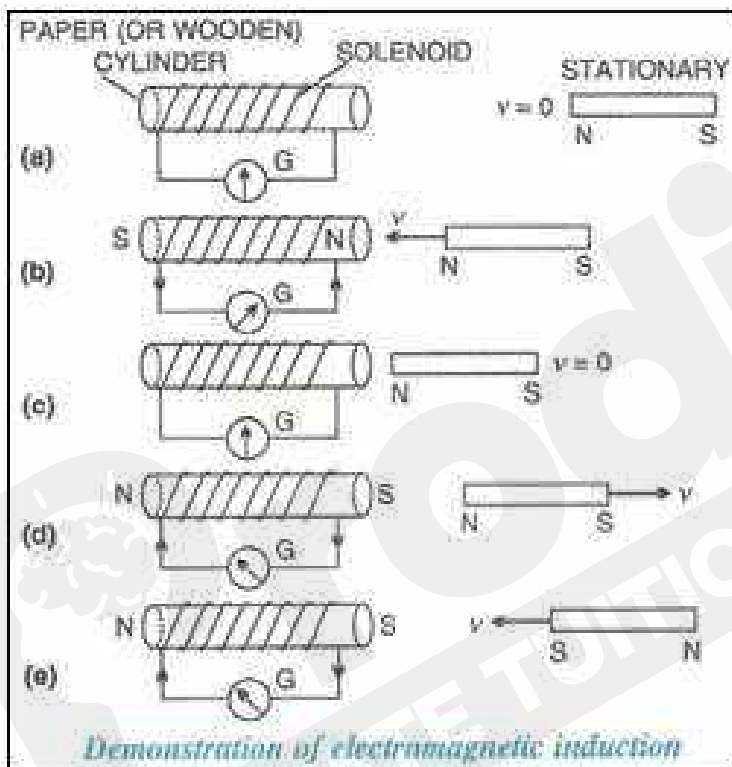
- **Factors affecting speed of rotation of coil:**
  - Strength of current – **Directly Proportional.**
  - Number of turns in the coil – **Directly Proportional.**
  - Strength of the magnetic field – **Directly Proportional.**
- **Thus, speed of rotation of coil can be increased by:**
  - Increasing the strength of current,
  - Increasing the area of coil, and
  - Increasing the number of turns in coil,
  - Increasing the strength of magnetic field.

## C) ELECTROMAGNETIC INDUCTION & ITS APPLICATIONS TO A.C. GENERATOR & TRANSFORMER.

### ➤ Electromagnetic induction:

- **Definition:** **Electromagnetic induction** is the phenomenon in which, an e.m.f. is induced between the ends of the coil, if there is a change in the magnetic flux linked with the coil, and lasts as long as this flux changes.

### ➤ Experiment:

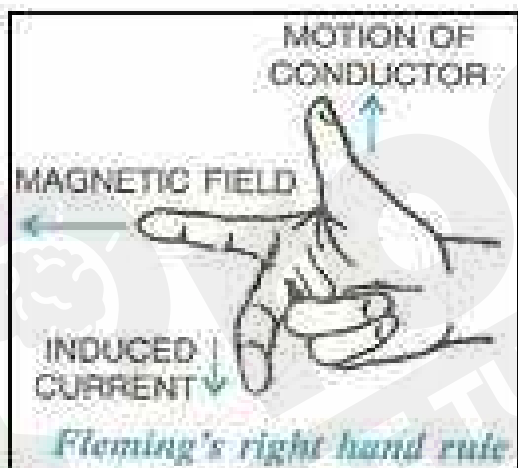


### ➤ Conclusion:

- A current will flow in the coil only if there is a relative motion between the coil and the magnet.
- The direction of deflection in galvanometer is reversed if either the direction of motion or polarity of the magnet is reversed.
- **The current in the coil is increased by:**
  - Rapid motion of the coil or magnet.
  - Use of a strong magnet
  - Increasing the area of coil or the number of turns in the coil.

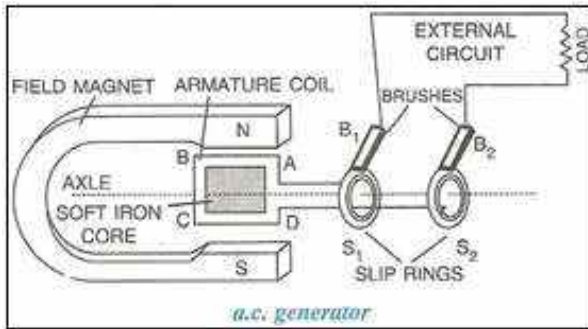
- **Faraday's laws of electromagnetic induction:** Faraday formulated following 2 laws:
  - If the circuit of the coil is closed, an e.m.f. gets induced, when there is a change in the magnetic flux linked with a coil, and it lasts as long as there is a change in the magnetic flux linked with the coil and current flows in the coil.
  - The magnitude of the e.m.f. induced is directly proportional to the rate of change of the magnetic flux linked with the coil.
    - **Note:** If the rate of change of the magnetic flux remains uniform, a steady e.m.f. is induced.

- **Direction of induced e.m.f.:** It can be obtained by any of the following two rules:
  - **Fleming's right hand rule:** It is the rule that governs the direction of induced current on the relative motion of conductor in a closed circuit, where the right hand forefinger indicates the direction of magnetic field, the thumb indicates the direction of motion of conductor and the central finger indicates the direction of induced current.



- **Lenz's law:** It states that the direction of induced e.m.f. or current is such that it tends to oppose the cause which produces it.
- **A.C. Generator:**
    - **Definition:** An a.c. generator is a device which works on the principle of electromagnetic induction and converts mechanical energy into electrical energy.
    - **Principle:** A coil rotated in a magnetic field changes the magnetic flux linked with the coil and induces an e.m.f. between the ends of the coil. The Fleming's Right hand rule is used to obtain the direction of induced current in the conductor.

○ **Main parts:**



○ **Main parts of an a.c. generator:**

- A horse shoe shaped electromagnet.
- An armature coil ABCD, mounted on an axle.
- Two metallic slip rings  $S_1$  and  $S_2$ .
- Two carbon brushes  $B_1$  and  $B_2$ .

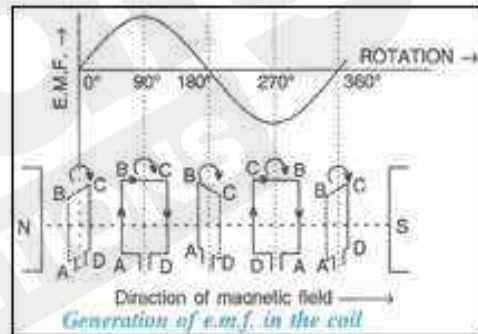
○ **The induced e.m.f with respect to the position of the coil:**

▪ **When the plane of the coil is normal to the magnetic field:**

- The magnetic flux linked with the coil is maximum.
- The rate of change of magnetic flux is zero.
- So the e.m.f. induced in the coil is zero.

▪ **When the plane of the coil becomes parallel to the magnetic field:**

- The magnetic flux linked with the coil becomes zero.
- The rate of change of magnetic flux is maximum.
- So the e.m.f. induced in the coil becomes maximum.



○ **The induced e.m.f can be increased by:**

- Increase in speed of rotation of the coil.
- Increase in number of turns of the coil.
- Increase in area of cross section of the coil.

➤ **Comparison of D.C and A.C.:**

Direct current	Alternating current
It is the current of uniform magnitude.	It is the current of varying magnitude with respect to time.
It has a unidirectional flow.	It reverses its direction after every half turn.
It is obtained from a cell or battery	It is obtained from a generator or mains.

➤ **Advantages of A.C. over D.C.:**

- A.C. can be easily changed to D.C.
- The voltage of A.C can be stepped up or stepped down easily using transformers.
- The voltage of A.C. can be stepped up and be transmitted over long distances at least current without loss in energy.

➤ **Comparison of A.C generator and a D.C motor:**

A.C. generator	D.C. generator
A generator converts the mechanical energy into the electrical energy.	A d.c. motor converts the electrical energy into the mechanical energy.
Principle of working: Electromagnetic induction.	Principle of working: Force acting on a current carrying conductor placed in a magnetic field.
A generator uses two separate coaxial slip rings.	A d.c. motor uses two commutator split rings (parts of a slip ring).

➤ **Similarity between an A.C. generator and D.C. motor:**

- Both has a coil rotating in a magnetic field between the pole pieces of a powerful electromagnet.
- Transformation of energy from one form to the other, takes place in both.

➤ **Transformer:**

- **Definition:** A transformer is a device which can increase or decrease the magnitude of an alternating e.m.f.
- **Principle:** A transformer works on the principle of electromagnetic induction on two coils having different number of turns.
- **Factors affecting the magnitude of e.m.f. induced in the secondary coil:**
  - The ratio of the number of turns in the secondary coil to the number of turns in the primary coil (i.e., turn ratio) – **Directly Proportional.**
  - The magnitude of e.m.f. applied in the primary coil or the input voltage. **Directly Proportional.**

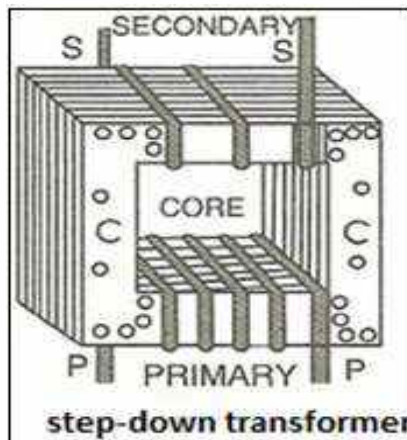
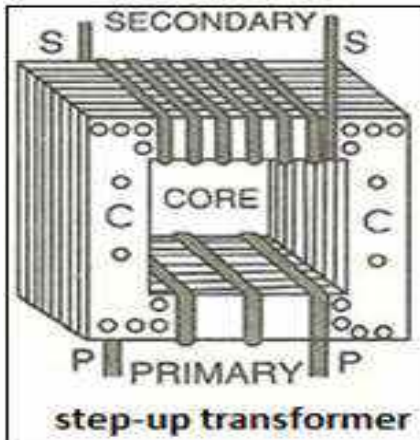
○ **In a transformer:**

- Turns ratio 
$$= \frac{\text{E.m.f. across the secondary coil } (E_S)}{\text{E.m.f. across the primary coil } (E_P)}$$

$$= \frac{\text{Number of turns in the secondary coil } (N_S)}{\text{Number of turns in the primary coil } (N_P)}$$

$$= \frac{\text{current in the primary coil } (I_P)}{\text{current in the secondary coil } (I_S)}$$
- Turn ratio 
$$= \frac{E_S}{E_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$

- **Types of transformer:** There are two types of transformers:



- **Differences:**

Step-up transformer	Step-down transformer
It increases the a.c. voltage and decreases the current.	It decreases the a.c. voltage and increases the current.
The turns ratio $> 1$ ; secondary coil has more no of turns than primary coil	Its turns ratio $< 1$ ; primary coil has more no of turns than secondary coil.
The wire of primary coil is thicker than secondary coil.	The wire in the secondary coil is thicker than primary coil.
Uses: at power generating station, with X-ray tubes, television, etc.	Uses: at power station, with night electric bulb, radio sets for valve heaters, transistors, etc.

➤ **FORMULAE:**

1. Turns ratio  $= \frac{N_s}{N_p}$
2.  $\frac{N_s}{N_p} = \frac{E_s}{E_p}$
3.  $E_s \cdot I_s = E_p \cdot I_p$
4.  $\Delta B$  = Change in magnetic flux
5. emf  $= N \times \frac{\Delta B}{t}$