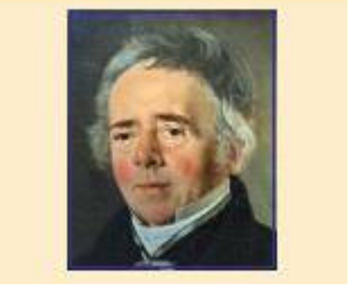
PHYSICS

CHAPTER 2 – MAGNETIC EEFECT OF ELECTRIC CURRENT

Magnetic field around a current carrying conductor

- **Whenever a current is passed through a conductor a magnetic field is developed around it**
- **Such magnets are called electromagnets**
- **The magnetic field lines of bar magnet and that of electromagnet are same.**
- **The presence of magnetic field and polarity can be understood using a compass**
- **The magnetic strength / magnetism of an electromagnet is temporary, i.e without current magnetic field is not developed around the conductor.**
- **It was first found by Hans Christian Oersted**

Hans Christian Oersted (1777-1851)



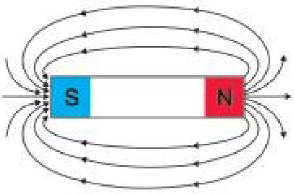


Fig. 2.1

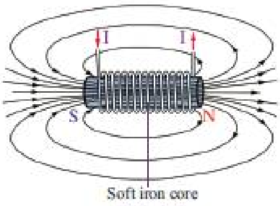


Fig. 2.2

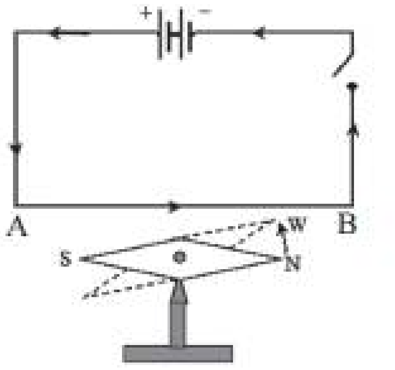


Fig. 2.3 (a)

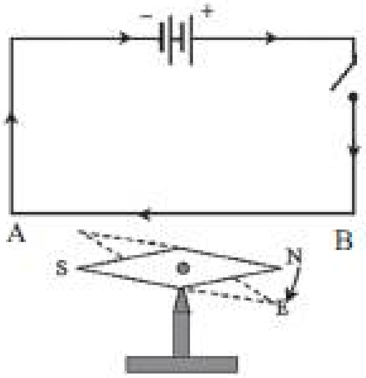


Fig. 2.3 (b)

No.	Conductor above the magnetic needle	Direction of motion of North Pole (N) of the magnetic needle clockwise/anticlockwise
1	Direction of current from A to B	**Anticlockwise**
2	Direction of current from B to A	**Clockwise**

Table 2.1

No.	Conductor below the magnetic needle	Direction of motion of North Pole (N) of the magnetic needle clockwise/anticlockwise
1	Direction of current from A to B	Clockwise
2	Direction of current from B to A	Anticlockwise

Table 2.2

Direction of magnetic field around a current carrying conductor

Right Hand Thumb Rule

What we have understood is the ***Right Hand Thumb Rule*** *of James Clark Maxwell. Imagine you are holding a current carrying conductor with the right hand in such a way, that the thumb points in the direction of the current. The direction in which the other fingers encircle the conductor gives the direction of the magnetic field.*

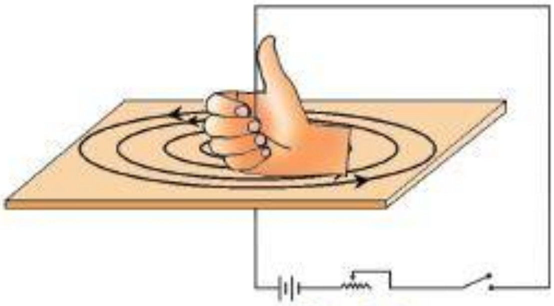
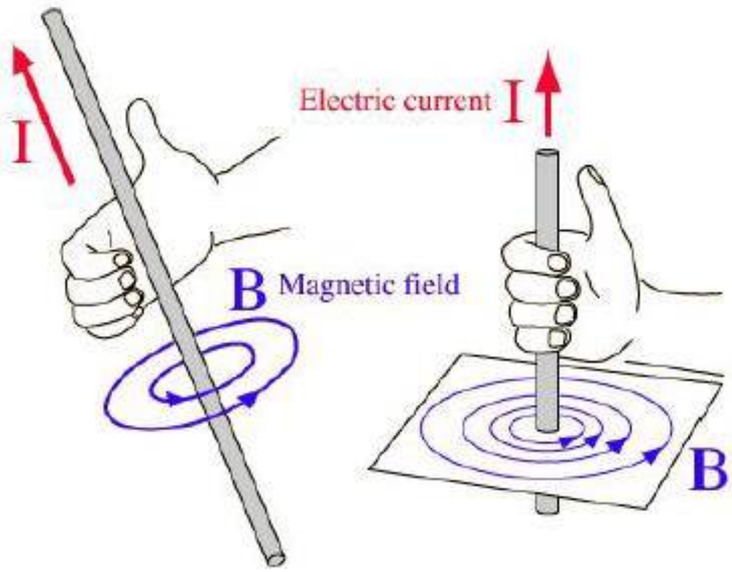
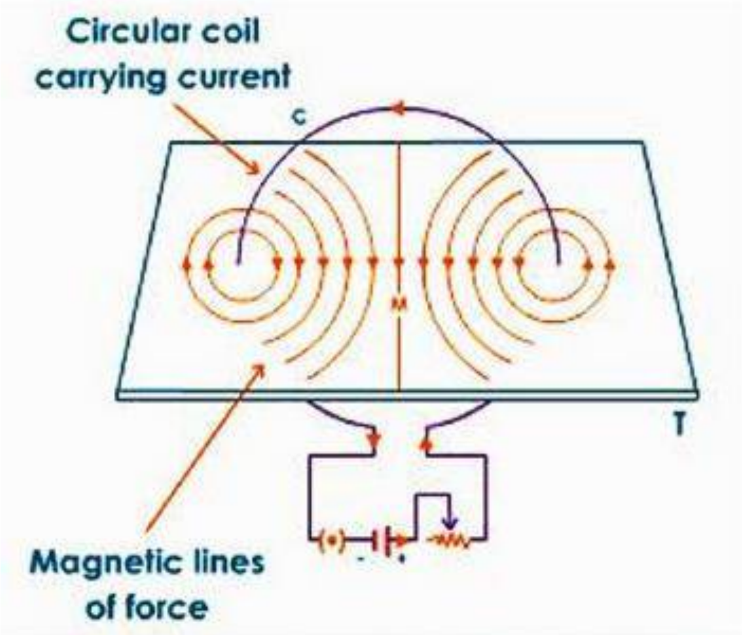


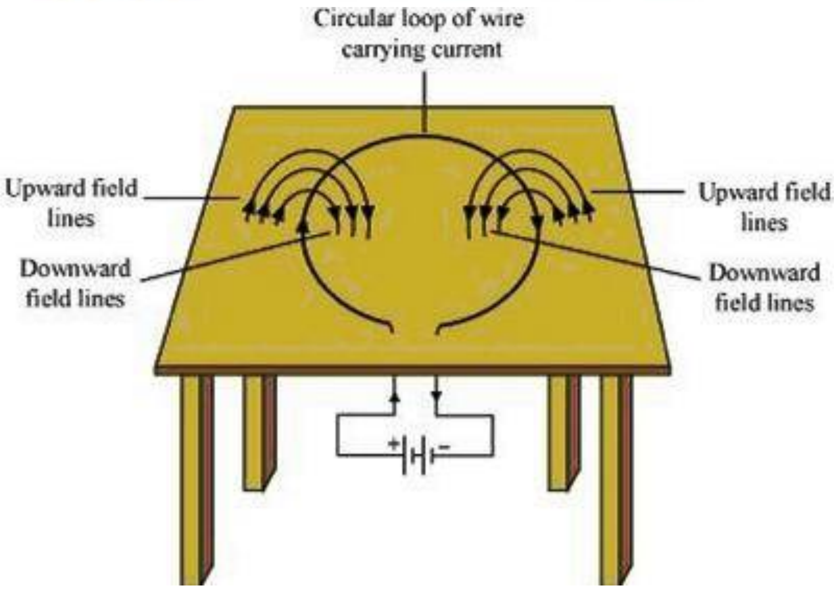
Fig. 2.5



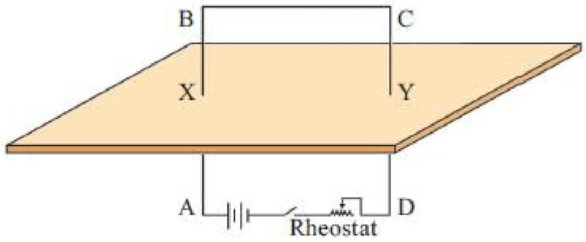
Right Hand Screw Rule

The same rule is also known as Right Hand Screw Rule. If a right hand screw is rotated in such a way that its tip advances along the direction of the current in the conductor, then the direction of rotation of the screw gives the direction of the magnetic field around the conductor.





Q) consider the following figure



a) **What is the direction of current in conductor AB?**
(A to B, B to A)
Ans) A to B

b) **The magnetic field around X is in _____________ direction**
(clockwise, anticlockwise)
Ans) anticlockwise direction

c) **Name the law used to find the direction of magnetic field?**
Right Hand Thumb Rule

<u>Magnetic field around a circular coil</u>

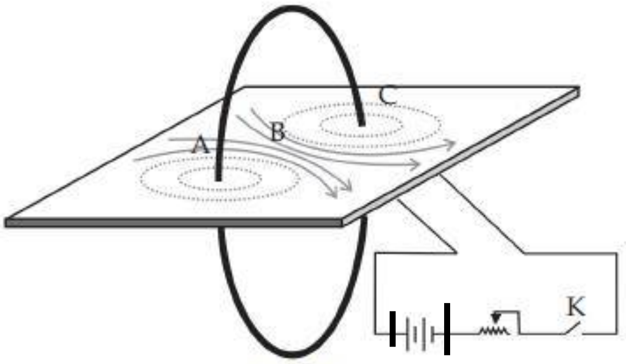


Fig. 2.6

When the electric current passes in the clockwise direction, the magnetic field lines appear to move away from us into the coil through the central part of the coil. But if the electric current passes in the anti clockwise direction, the magnetic field lines appear to move out towards us from the coil through its centre.

The magnetic field lines are circular near the current carrying loop. As we move away, the concentric circles becomes bigger and bigger. At the centre, the lines are straight.
At the centre, all the magnetic field lines are in the same direction due to which the strength of magnetic field increase.
The magnetic of magnetic field produced by a current carrying circular loop at its centre is

- directly proportional to the current passing
- inversely proportional to the radius of the circular loop

The strength of magnetic field produced by a circular coil carrying current is directly proportional to both number of turns(n) and current(I) but inversely proportional to its radius(r).

Q) how will you increase the strength of magnetic field around a conductor?

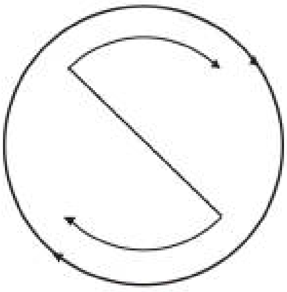
Ans) by increasing the number of turns of the coil, by increasing the intensity of current flowing through the conductor

<u>Solenoid</u>

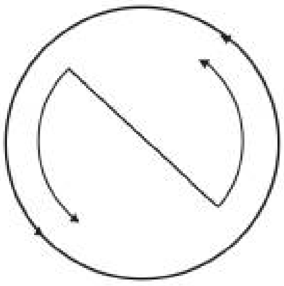
A solenoid is an insulated wire wound in the shape of a helix. Such coiled conductors are used to make use of the magnetic effect of electricity.

Fig. 2.8 (a)

The end of the solenoid at which current flows in the clockwise direction will be the South Pole and the end at which current flows in the anticlockwise direction will be the North Pole.



Current in the clockwise direction

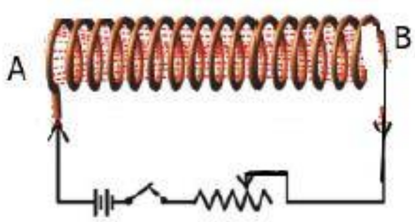


Current in the anti clockwise direction

The strength of magnetic field produced by a carrying current solenoid depends on

- number of turns(n)
- strength of current(I)
- nature of core material used in solenoid – use of soft iron as core in a solenoid produces the strongest magnetism

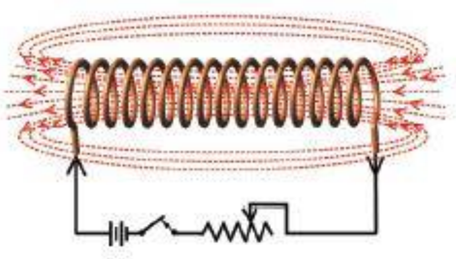
Q) identify the magnetic polarity at the points A and B in the solenoid



A- South pole, current enters in clockwise direction
B- North pole, current enters in anticlockwise direction

Q) What are the differences between solenoid and bar magnet?

Solenoid	**Bar Magnet**
Electromagnet	Permanent magnet
1. An electromagnet is a temporary magnet as it can readily demagnetized by stopping the current through the solenoid.	1. A permanent magnet cannot be readily demagnetized.
2. Strength can be changed.	2. Strength cannot be changed.
3. It produces very strong magnetic forces.	3. It produces weal forces of attraction.
4. Polarity can be changed by changing the direction of the current.	4. Polarity is fixed and cannot be changed.



<u>Force developed in a current carrying conductor placed in a magnetic field</u>

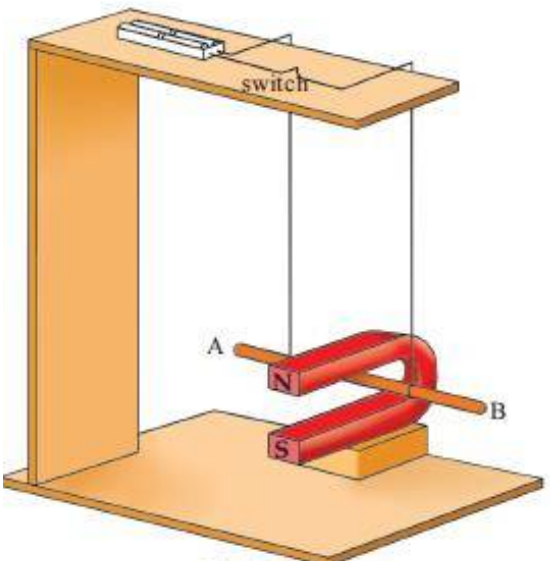


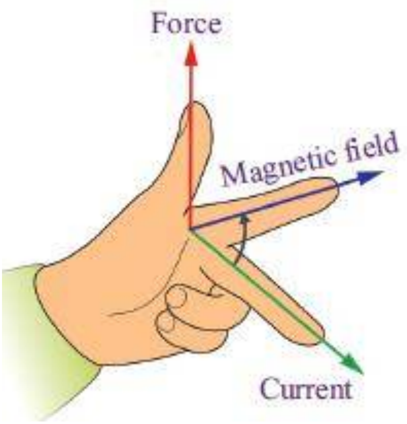
Fig. 2.10

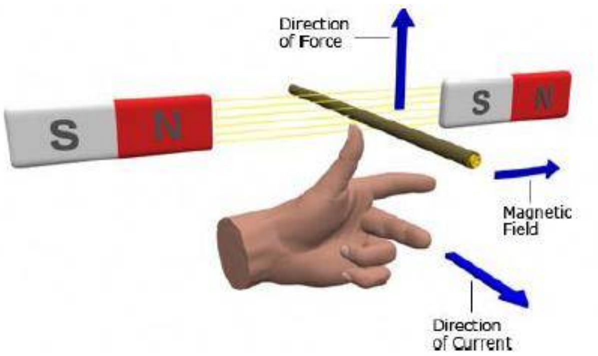
When the switch is put ON then a current will flow through the conductor from A to B now this current will produce a magnetic field around the conductor, it will attract or repel with the external magnetic field (u shaped magnet) as a result a force will experienced by the conductor, it will move away from its mean position.

- **If the direction of current is reversed the direction of motion of conductor also reversed**
- **If the polarity of U-shaped magnet is reversed the direction of motion of conductor also reversed**
- **By increasing the current through the conductor, we can increase the force**
- **The direction of motion of the conductor/ force is given by Fleming's left Hand Rule**

Fleming's Left Hand Rule

Hold the forefinger, the middle finger and the thumb of the left hand in mutually perpendicular directions as shown in the figure. If the forefinger indicates the direction of the magnetic field and the middle finger, the direction of the current, then the thumb will indicate the direction of motion of the conductor.





Motor principle

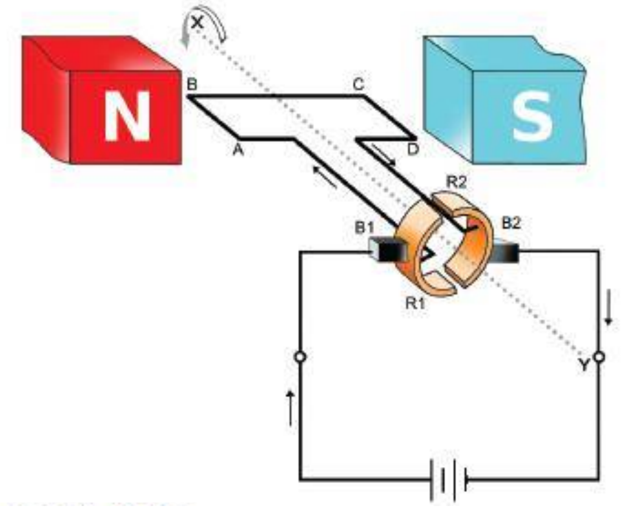
A conductor, which can move freely and which is kept in a magnetic field, experiences a force when current passes through it and it moves.

Q) name some devices which will works based on motor principle

Ans) Electric Motor, Moving Coil Loud Speaker

Electric Motor

Structure



Parts of motor

N,S – field magnets, they are stationary

ABCD coil – Armature coil, rotating part

R1, R2 – split rings

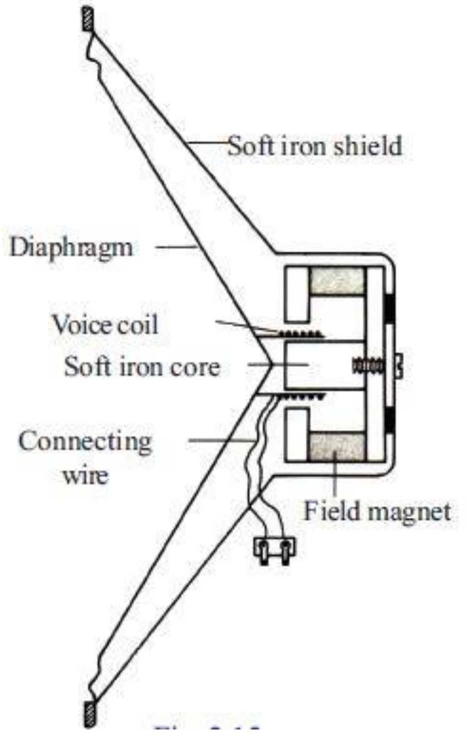
B1, B2 – brushes

Working

Whenever current flows through the armature coil a magnetic filed is developed around it and it will experince a force due to field magent, the armature coil start to rotate. After every half rotation the split ring helps to change the direction of current through the coil and hence it will help for the continuous rotation of armature.

Moving Coil Loud Speaker

Struccture



Parts of loud speaker

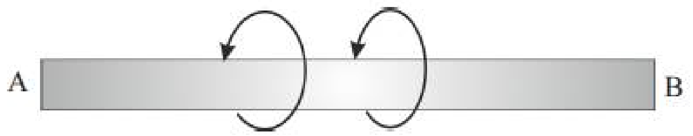
- **Diaphragm**
- **Voice coil**
- **Field magnet**
- **Connecting wires**
- **Soft iron shield**
- **Soft iron core (to increase magnetic field strength)**

Working

The electrical pulses from a microphone are strengthened using an amplifier and sent through the voice coil of a loudspeaker. The voice coil, which is placed in the magnetic field, moves to and fro rapidly, in accordance with the electrical pulses. These movements make the diaphragm vibrate, thereby reproducing sound.

QUESTIONS FOR PRACTIES

4. The magnetic field around the current carrying conductor AB is depicted.



Based on the Maxwell's Right Hand Cork Screw Rule find out the direction of current and record it.

(hint: from B to A)

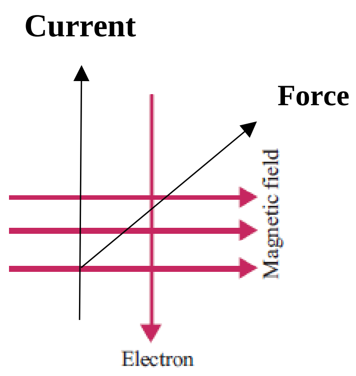
5. Electricity flows through a very long solenoid. Some statements are given below related to the magnitude of the magnetic field developed. Find out the correct ones and write them down.

a) It is zero
b) It will be the same at all points
c) It gradually decreases towards the ends.
d) It gradually increases towards the ends.

(hint: it will be same at all points)

6. The direction of movement of electrons through a magnetic field is depicted.

"The force felt by the electrons due to the influence of the magnetic field is into the plane of the paper". Is this statement correct? Explain based on the Fleming's Left Hand Rule.



(Hint: TRUE)

10. State the Motor Rule. If the directions of current in the conductor and the magnetic field are the same, in which way will the conductor move?

(Hint: if both the directions are same then there will be no resultant force(net force = 0) so the conductor will not move)

Which of the following correctly describes the magnetic field near a long straight wire?

(a) The field consists of straight lines perpendicular to the wire

(b) The field consists of straight lines parallel to the wire

(c) The field consists of radial lines originating from the wire

(d) The field consists of concentric circles centred on the wire

Ans. (d) The magnetic field lines, produced around a straight current-carrying conductor, are concentric circles. Their centres lie on the wire.

. State the rule to determine the direction of a (i) magnetic field produced around a straight conductor-carrying current, (ii) force experienced by a current-carrying straight conductor placed in a magnetic field which is perpendicular to it, and (iii) current induced in a coil due to its rotation in a magnetic field.

Ans. (i) Maxwell's right hand thumb rule

(ii) Fleming's left hand rule

(iii) Fleming's right hand rule