MAGNETIC EFFECTS OF ELECTRIC CURRENT

Gist of the Lesson

Magnet:

(i) It is an object that attracts objects made of iron, cobalt & nickel.

(ii)Comes to rest in North-South direction, when suspended freely.

Magnets are used:

(i) In radio & stereo speakers.

(ii) In refrigerator doors.

(iii) On audio & video cassettes players.

(iv) On hard discs & floppies of computers &

(v) In children's toys.

Magnetic Field: The area around a magnet where a magnetic force is experienced is called a Magnetic Field. It is a quantity that has both direction & magnitude.

Magnetic Field Lines: Magnetic field is represented by field lines. They are lines drawn in a Magnetic field along which a North magnetic pole moves. Magnetic field lines are called as Magnetic lines of force.

Properties of Magnetic Field Lines:

(i) They do not intersect each other.

(ii) It is taken by convention that magnetic field lines emerge from North Pole and merge at the South Pole. Inside the magnet, their direction is from South Pole to North Pole. Therefore magnetic field lines are closed curves.

Magnetic field lines due to a current through a straight conductor (wire)-consist of series of concentric circles whose direction is given by the Right hand thumb rule.

Right Hand Thumb Rule: If a current carrying straight conductor is held in your right hand such that the thumb points towards the direction of current, then the wrapped fingers show the direction of magnetic field lines.

The strength of the magnetic field at the centre of the loop (coil) depends on:

(i) **The radius of the Coil:** The strength of the magnetic field is inversely proportional to the radius of the coil. If the radius increases, the magnetic strength at the centre decreases.

(ii) **The number of turns in the Coil:** As the number of turns in the coil increase, the magnetic strength at the centre increases, because the current in each circular turn is having the same direction, thus the field due to each turn adds up.

(iii) **The strength of the current flowing in the coil:** as the strength of the current increases, the strength of the magnetic fields also increases a Solenoid.

Solenoid:

(i) A coil of many turns of insulated copper wire wrapped in the shape of a cylinder is called a Solenoid.

(ii) Magnetic field produced by a Solenoid is similar to a bar magnet.

(iii) The strength of magnetic field is proportional to the number of turns & magnitude of current.

Electromagnet: An electromagnet consists of a long coil of insulated copper wire wrapped on a soft iron core.

Fleming's left hand rule: Stretch the thumb, forefinger and middle finger of left hand such that they are mutually perpendicular. Forefinger points in the direction of magnetic field and centre finger in the direction of current, then the thumb gives the direction of force acting on the conductor.

Electric Motor: A device that convert electric energy to mechanical energy.

Principle of Electric Motor: When a rectangular coil is placed in a magnetic field and a current is passed through it, force acts on the coil, which rotates it continuously. With the rotation of the coil, the shaft attached to it also rotates.

Electromagnetic Induction: Electricity production as a result of magnetism (induced current) is called Electromagnetic induction.

Fleming's Right Hand Rule: gives the direction of induced current. Stretch the thumb, forefinger and middle finger of right hand such that they are mutually perpendicular. Forefinger points in the direction of magnetic field and centre

finger in the direction of induced current, then the thumb gives the direction of motion of the conductor.

Electric Generator: Electric generator is of two types-

(i) A.C generator (ii) D. C generator.

Principle of Electric Generator: Electromagnetic induction.

Domestic Electric Circuits: We receive electric supply through mains supported through the poles or cables. In our house we receive AC electric power of 220V with a frequency of 50Hz.

The 3 wires are as follows-

(i) Live wire- (Red insulated, Positive)

(ii) Neutral wire- (Black insulated, Negative)

(iii) Earth wire- (Green insulated) for safety measure to ensure that any leakage of current to a metallic body does not give any serious shock to a user.

Short Circuit: is caused by touching of live wires and neutral wire.

Fuse: is a protective device used for protecting the circuits from short circuiting and over loading

Important Diagrams-

1. Magnetic field lines around a bar magnet.
2. Right hand thumb rule
3. Magnetic field lines through and around a current carrying solenoid.
4. An electromagnet.
5. A simple electric motor
6. Electric generator

Important Activities-

1. Magnetic field lines around a bar magnet
2. Direction of electric current in a simple electric circuit.
3. Direction of Magnetic field lines depends on the direction of electric current.

One Mark Questions (One word or one sentence)

1. What is a Magnet?

A. A magnet is a material which has both attractive and directive properties. It attracts small pieces of iron, nickel, cobalt, etc.

2. What is the surer test of Magnetism?

A. Repulsion is the surer test of magnetism.

3. Define the term Magnetic Field?

A. The region around a magnet in which its influence can be experienced is called its magnetic field.

4. What is magnetic effect of current?

A. A current carrying conductor produces magnetic field around it. This is called magnetic effect of current.

5. What is a Solenoid?

A. A long cylindrical coil of insulated copper wire of large number of circular turns is called a solenoid.

6. What is the effect of placing an iron core in a solenoid?

A. The magnetic field associated with the solenoid increases tremendously.

7. Name two alloys used for making permanent magnets?

A. Nipermag and alnico.

8. State Fleming's left hand rule (or motor rule)?

A. Stretch the forefinger, the central finger and the thumb of the left hand mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field, the central finger in the direction of current, then the thumb points in the direction of force on the conductor.

9. Is the charge at rest associated with any magnetic field?

A. No

10. What is the basic cause of induced *emf*?

A. The basic cause of induced *emf* is the change of magnetic flux linked with a closed circuit.

11. What is the function of commutator in a D.C. generator?

A. Split ring commutator of a D.C. generator converts the alternating current of its armature into a unidirectional current in the external circuit.

12. Name the essential parts of an A.C. generator?

A. (i) Field magnet (ii) Armature (iii) Slip rings (iv) Brushes and (v) Load resistance.

Two Marks Questions (30 words)

1. How does the strength of the magnetic field at the centre of a circular coil of wire depend on?

(i) The radius of the coil,

(ii) The number of turns of wire in the coil, and

(iii) The strength of current flowing in the coil?

A. The magnetic field produced at the centre of circular coil carrying coil depends on following factors:

(i) It is inversely proportional to the radius of the coil. That is,

$$B \propto \frac{1}{r}$$

(ii) It is directly proportional to the number of turn's n of the coil. As the direction of current in each circular turn is same, the fields due to the various turns get added up.

That is,

$$B \propto n$$

(iii) It is directly proportional to the strength of current passing the coil.

That is,

$$B \propto I$$

2. Give some advantages of electromagnets over permanent magnets?

A. An electromagnet has following advantages over a permanent magnet:

(i) An electromagnet can produce a very strong magnetic field.

(ii) The strength of the magnetic field of an electromagnet can be increased/decreased by increasing/decreasing the strength of current or the number of turns in the solenoid.

(iii) The polarity of an electromagnet can be reversed by sending the current in the reverse direction.

Three Marks Questions (50 words)

1. Give some basic properties of magnets?

A. Some basic properties of magnets are as follows:

(i) Attractive Property: A magnet attracts small pieces of iron, cobalt, nickel, etc.

(ii) Directive Property: A freely suspended magnet aligns itself nearly in the north- south direction.

(iii) Law of Magnetic Poles: Like magnetic poles repel and unlike magnetic poles attract each other.

(iv) Magnetic poles exist in pairs: If we break a magnet into two pieces, we always get two small dipole magnets. It is not possible to obtain an isolated N-pole or S-pole.

2. What are artificial magnets? What are their common shapes?

A. **Artificial Magnets:** Pieces of iron and other magnetic materials can be made to acquire the properties of natural magnets. Such magnets are called artificial magnets.

The most common shapes of the artificial magnet are bar magnet, horse shoe magnet and magnetic needle, as shown in Fig. 13.1.

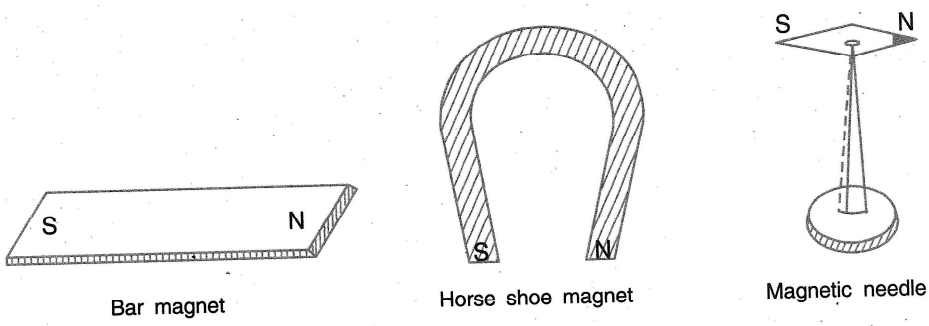

Fig. 13.1. *Artificial magnets in different shapes*

3. Mention some important uses of magnets in everyday life?

A. **Uses of Magnets:**

(i) Magnets are used in radio and stereo speakers.

(ii) They are used in almirah and refrigerator doors to snap them closed.

(iii) They are used in video and audio cassette tapes, on the hard discs and floppies for computers.

(iv) In children's toys.

(v) In medicine, the magnetic resonance imaging (MRI) scanners expose the inner parts of the patient's body for detailed examination by doctors.

4. What are magnetic lines of force? Give their important properties?

A. Magnetic lines of force: A magnetic line of force may be defined as the curve the tangent to which at any point gives the direction of the magnetic field at that point. It may also be defined as the path along with a free north pole tends to move.

Properties of Lines 0f Force:

(i) These are closed curves which start in air from the N-pole and end at the S-pole and then return to the N-pole through the interior of the magnet.

(ii) No two magnetic lines of force can intersect each other.

(iii) They start from and end on the surface of the magnet normally.

(iv) The lines of force have a tendency to contract lengthwise and expand sidewise. This explains attraction between unlike poles and repulsion between like poles.

(v) The relative closeness of the lines of force gives a measure of the strength of the magnetic field which is maximum at the poles.

5. Distinguish between the terms 'overloading' and 'short-circuiting' as used in domestic circuits?

A. **Short Circuiting:** If due to defective or damaged wiring, the live and neutral wires come in direct contact, the resistance of the circuit becomes almost zero and an extremely large current flows through the circuit. This is called short circuiting. It results in heating the line wires and may damage the appliance. It may produce spark at the place of short circuit and cause fire. Short circuiting can be prevented by using an electric fuse in live wire.

Overloading: When a large number of high power appliances are switched on simultaneously, they draw extremely large current from the mains. If the current

drawn from the mains exceeds the safety limit (5 A for domestic line and 15 A for power line), then this is known as overloading. As a result of overloading, the wires get over heated and the appliances may get damaged. This can be avoided by using an electric fuse in live wire.

Five Marks Questions (70 words)

1. What is an electromagnet? On factors does the strength of an electromagnet depend? (Or)
What is an electromagnet? Draw a circuit diagram to show how a soft iron piece can be transformed into an electromagnet?

A. **Electromagnet:** A soft iron core placed inside a solenoid behaves like a powerful magnet when a current is passed through the solenoid. This device is called an electromagnet. When the current is switched off, the iron core loses its magnetism and so it is no longer an electromagnet. Thus, electromagnets are temporary magnets. See Fig.

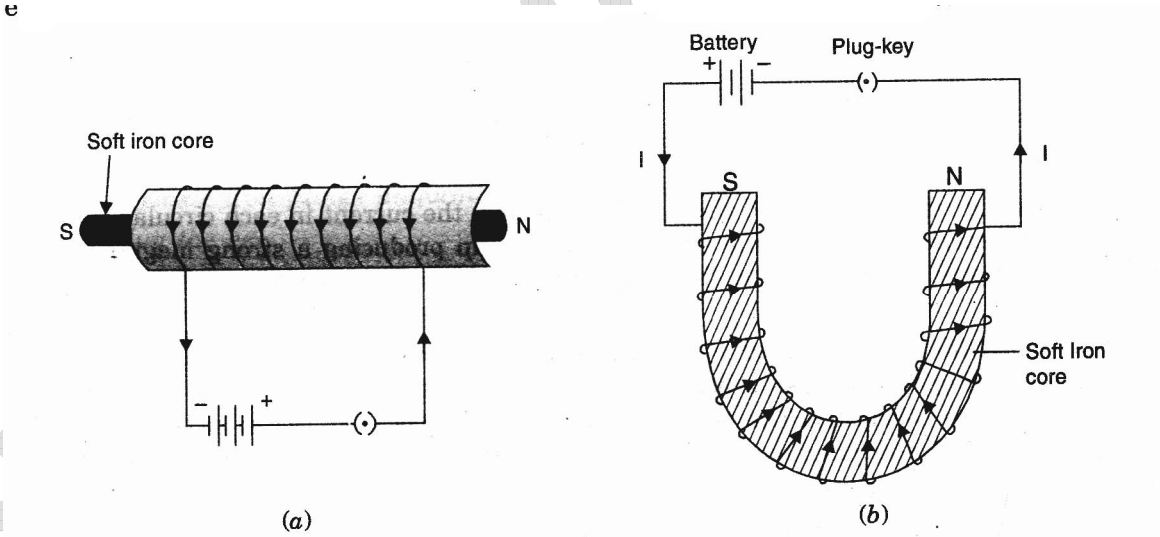

Fig. 13.17. *Electromagnet (a) Bar type (b) Horse-shoe type*

Factors on which the strength of an electromagnet depends:

(i) Number of turns in the Coil: The larger the number of turns in the coil, greater is the strength of the electromagnet.

(ii) Strength of the Current: The larger the current passed through the solenoid, more powerful is the electromagnet.

(iii) Nature of the Core Material: The core of the magnetic material like soft iron increases the strength of the electromagnet.

2. with the help of a labelled diagram, explain the principle, construction and working of an electric motor. What is the function of a split ring in an electric motor?

A. **Electric Motor:** We describe here a D.C. motor which operates on direct current obtained from a battery.

Principle: An electric motor works on the principle that a current carrying conductor placed in a magnetic field experiences a force, the direction of force is given by Fleming's left hand rule.

Construction: As shown in Fig. 13.23, an electric motor consists of the following main parts:

1. **Field Magnet:** It is a strong horse shoe type magnet with concave poles.
2. **Armature:** It is a rectangular coil ABCD having a large number of turns of thin insulated copper wire wound over a soft iron core. The armature is placed between the poles of the field magnet and it can be rotated about an axis perpendicular to the magnetic field lines.

lines.

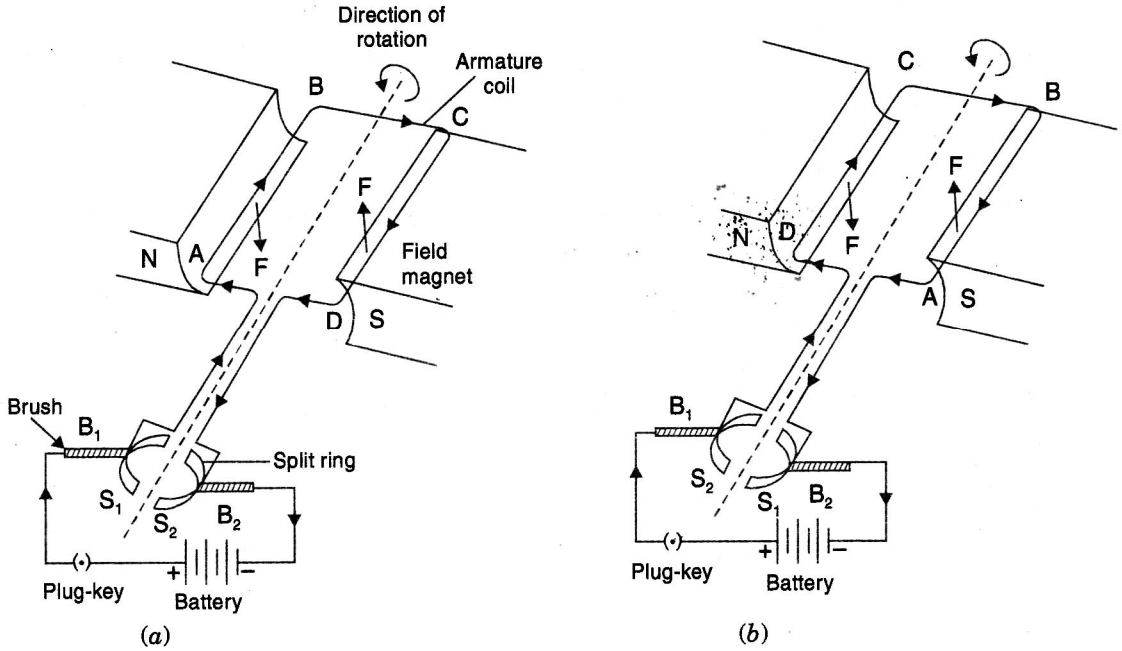

Fig. 13.24. *An electric d.c. motor*

3. **Split ring Commutator:** It consists of a cylindrical metal ring 8plit into two halves S1 and S_2. The two ends A and D of the armature coil are connected

to the split rings S_1 and S_2 respectively. As the coil rotates, the split rings also rotate about the same axis of rotation. The function of the split ring commutator is to reverse the direction of current in the coil after every half rotation.

4. **Brushes:** Two graphite or flexible metal rods maintain a sliding contact with split rings S_1 and S_2, alternately.

5. **Battery:** A battery of few cells is connected to the brushes. The current from the battery flows to the armature coil through the brushes and the split rings.

Working: Initially, suppose the plane of the coil is horizontal. The split ring S_1 touches the brush B_1 and split ring S_2 touches the brush B_2. The current in coil flows in the direction ABCD, as shown in Fig. 13.24 (a).

Clearly, the currents in arms AB and CD are in opposite directions. On applying Fleming's left hand rule for the direction of force on a current-carrying conductor in a magnetic field, we find that the force acting on arm AB pushes it downwards while the force acting on the arm CD pushes it upwards. Thus the armature coil along with the axle rotates anticlockwise. After half a rotation, as shown in Fig. 13.24 (b), the split ring S_1 comes in contact with brush B_2 and S_2 in contact with brush B_1. Therefore, the current in the coil gets reversed and flows along the path DCBA. A device that reverses the direction of flow of current through a circuit is called commutator. In electric motors, the split ring acts as a commutator. Thus the arm AB is now pushed up and the arm CD are pushed down. Therefore, the coil and the axle rotate half a turn more in the same direction. The reversing of the current is repeated at each half rotation, giving rise to a continuous rotation of the coil and to the axle.

3. Draw a labelled diagram to explain the principle underlying the working of an electric generator?

A. **A.C. Generator:** It is a device which converts mechanical energy into alternating form of electrical energy.

Principle: It works on the principle of electromagnetic induction. When a closed coil is rotated in a uniform magnetic field with its axis perpendicular to the

magnetic field, the magnetic field lines passing through the coil change and an induced emf and hence a current is Set-up in it.

Construction: It consists of the following main parts:

1. **Field Magnet:** It is a strong horse shoe-type permanent magnet with concave poles.
2. **Armature:** ABCD is a rectangular armature coil. It consists of a large number of turns of insulated copper wire wound on a soft iron cylindrical core. It can be rotated about an axis perpendicular to the magnetic field of the field magnet.
3. **Slip Rings:** These are two brass rings S_1 and S_2 rigidly connected to the two ends of the armature coil. As the coil rotates, slip rings also rotate about the same axis of rotation.
4. **Brushes:** These are two graphite rods B_1 and B_2 which are kept pressed against the slip rings S_1 and S_2. Through these brushes, the current induced in the armature coil is sent to the external circuit.

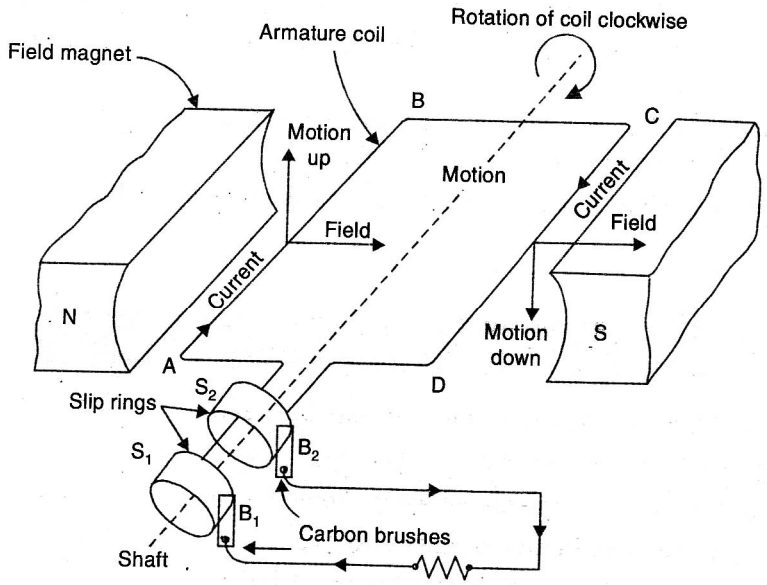

Fig. 13.30. *A.C. generator*

Working: As shown in Fig. 13.30, suppose the armature coil ABCD is in the horizontal position. Now the coil is rotated clockwise. The coil cuts the magnetic lines of force. The arm AB moves upwards while the arm CD moves downwards. According to Fleming's right hand rule, the induced current flows from A to B in arm AB and C to D in arm CD. i.e., the induced current flows along ABCD. The

induced current flows in the circuit through brush B_2 to B_1. After half the rotation of the armature, the arm CD moves upwards and AR moves downwards. The induced current now flows in the reverse direction i.e.., along DCBA the current flows from B_1 to B_2. Thus the direction of current in the external circuit changes after every half rotation. Such a current which changes its direction after equal intervals of time is called alternating current. This device is called A.C. generator.

//o0o