JAIPUR EDUCATION PLUS

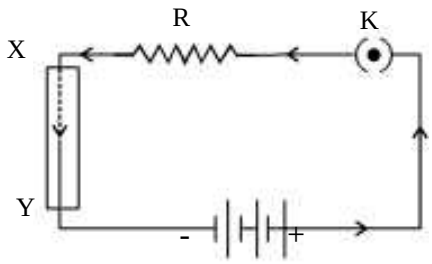
MAGNETIC EFFECTS OF ELECTRIC CURRENT

1. **Hans Christian Oersted (1777-1851)**

   Oersted showed that electricity and magnetism are related to each other. His research later used in radio, television etc.

   The unit of magnetic field strength is name Oersted in his honour.

2. **Oersted Experiment**



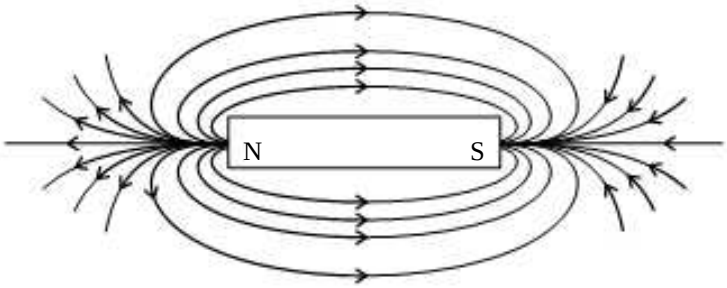
XY is conductor (Cu wire) through which current is passed

On passing the current through the copper wire XY in the circuit, the compass needle which is placed near the conductor gets deflected. If we reverse the direction of current, the compass needle deflect in reverse direction. If we stop the flow of current, the needle comes at rest.

Hence, it conclude that electricity and magnetism are linked to each other. It shows that whenever the current will flow through the conductor, then magnetic field around. it will developer

3. **Magnetic Field -** It is the region surrounding a magnet, in which force of magnet can be detected. It is a vector quantity, having both direction & magnitude.
4. Compass needle- It is a small bar magnet, whose north end is pointing towards north pole and south end is pointing towards south pole of earth.
5. **Magnetic field lines-**

   When a bar magnet is placed on a card board and iron fillings are sprinkled, they will arrange themselves in a pattern as shown below.



The lines along which the iron filling align themselves represent magnetic field lines.

Hence, magnetic field line is a path along which a hypothetical free north pole tend to move towards south pole.

6. **Characteristics of Magnetic field lines :**

(1) The direction of magnetic field lines outside the magnet is always from north pole to south pole of bar magnet and are indicated by an arrow.

Inside the magnetic, the direction of field lines is from its south pole to north pole

Thus magnetic field lines are closed curve

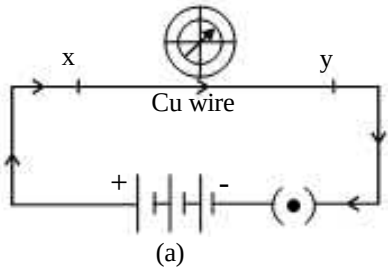
(2) The strength of magnetic field is expressed by the closeness of magnetic field lines. Closer the lines, more will be the strength and farther the lines, less will be the magnetic field strength.

(3) No two field lines will intersect each other.

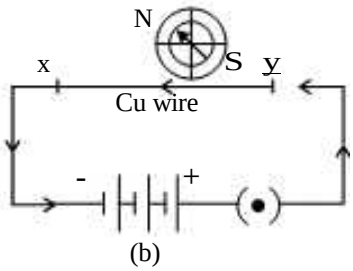
If they intersects, then at point of intersection the compass needle will show two direction of magnetic field which is not possible.

Tangent at the point of intersection shows two direction.

7. **Magnetic field due to Current Carrying Conductor**



(a)



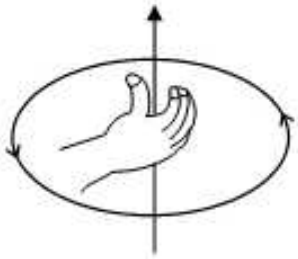
(b)

The above electric circuit in which a copper is placed paralled to a compass needle, shows the deflection in needle gets reversed, when the direction of current reversed. Hence electricity and magnetism are related to each other.

8. **Right Hand Thumb Rule :-**

It is a convenient way of finding the direction of magnetic field associated with current carrying conductor.

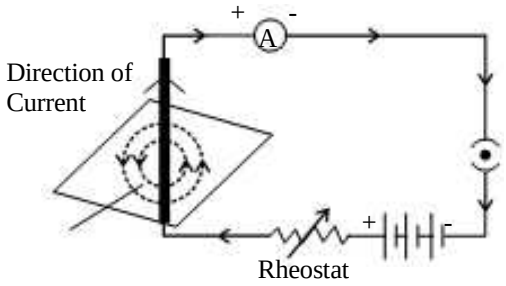
Hold the straight were carrying current in your right hand such that thumb points towards the direction of current, then your folded fingers around the conductor will show the direction of magnetic field.



Direction of magnetic field lines.

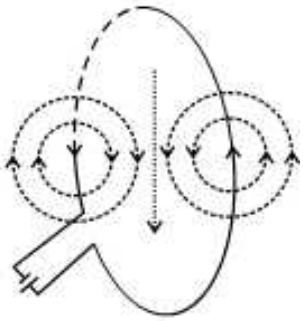
This rule is also called Maxwell's corkscrew rule.

9. **Magnetic Field due to Current through a Straight Conductor**



Direction can be explained using Right Hand Thumb Rule

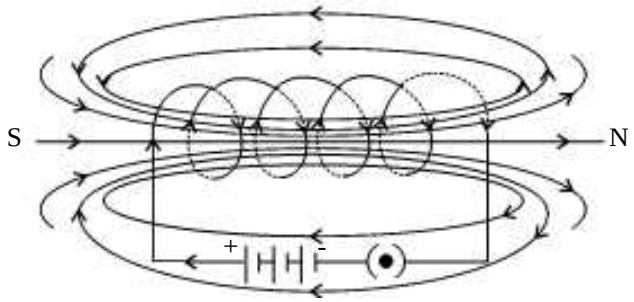
10. **Magnetic Field due to Current through a circular Loop**



Every point on the wire carrying current give rise to the magnetic field, appearing as a straight line at the centre of loop. By applying Right hand Thumb rule, we can find the direction of magnetic field at every section of the wire.

11. Solenoid- A Coil of many circular turns of insulated copper wire wrapped closely in the shape of a cylinder is called solenoid.

12. **Magnetic field due to a current in a solenoid-**



-Using R.H. Thumb Rule, we can draw the pattern of magnetic field lives around a current carrying solenod.

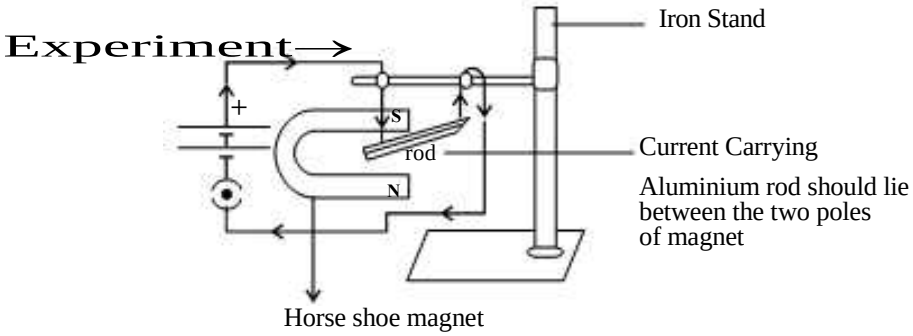
-One end of the solenoid behaves as a magnetic north pole, white the other end behave as the South Pole.

-The filed lines inside the solenoid are in form of parallel straigh lines, that implies that magnetic field inside the solenoid is same at all points i.e. Field is uniform.

13. **Electromagnet-** Strong magnetic field inside the solenoid can be used to magnetise a magnetic material for example soft iron, when it is placed inside the coil. The magnet so formed is called electromagnet.

14. **Force on a current carrying conductor in a magnetic field.**

Andre Marie Ampere (1775-1836) suggested that the magnet also exert an equal and opposite force on the current carrying conductor.

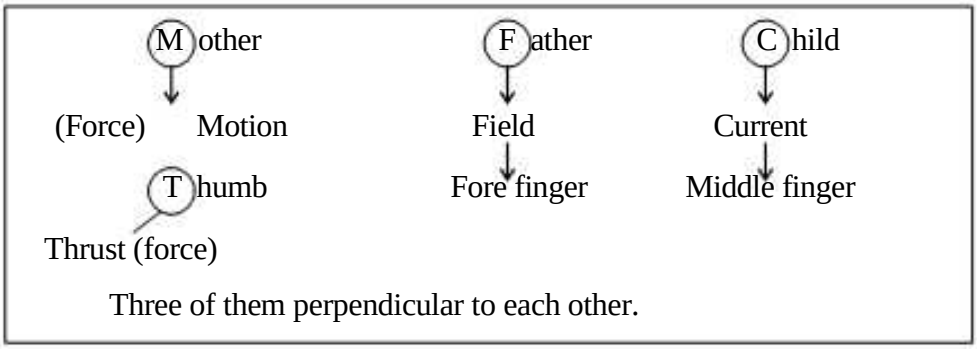


- We will observe that the rod will displace i.e. the rod will experience a force, when it is placed in magnetic field, in a perpendicular direction to its length.
- The direction of the exert force will be reversed if the direction of current through the conductor is reversed.
- If we change the direction of field by inter changing the two poles of the magnet, again the direction of exert force will change.
- Therefore the direction of exerted force depends on

(1) Direction of current

(2) Direction of magnetic field lines.

15. **Left Hand Fleming Rule**



- According to this rule, stretch thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular to each other.

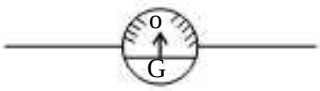
  If fore finger represent direction of magnetic field & middle finger represent direction of current, then thumb will point in the direction motion or force acting on the conductor.

- Functioning of electric motor is based on this rule. It convert electrical energy into mechanical energy.

16. **Michael Faraday**- Gave the law of **Electro magnetic Induction**

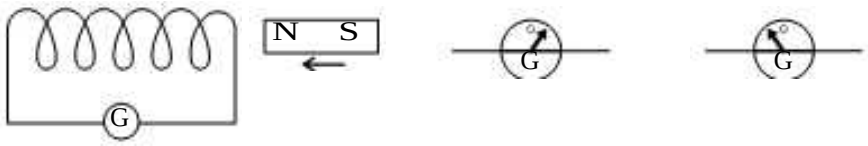
17. **Galvanometer** It is an instrument that can detect the presence of a current in a circuit. If pointer is at zero (the centre of scale) the there will be no flow of current.

    If the pointer deflect on either side right or left, this will show the direction of current. Represented by



18. **Electro Magnetic Induction -** Can be explained by two experiments

(a) FIRST EXPERIMENT "SELF INDUCTION"



In this experiment, when the north pole of bar magnet is brought closes to the coil or away from the coil, we see momentary deflection in the needle of galvanometer on either side of null point. First right and then left.

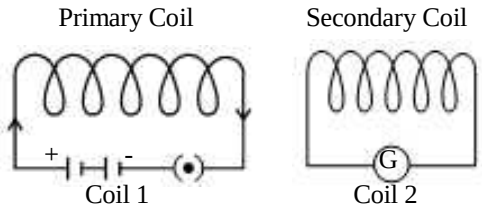
Similarly, if we keep the magnet stationary and coil is made to move towards or away from the north pole of magnet. Again we will observe deflection in the needle of galvanometer.

If both bar magnet and coil kept stationary, there will be no deflection in galvanometer.

This experiment can also be done with the south pole of magnet, we will observe the deflection in galvanometer, but it would be in opposite direction to the previous case.

It concludes that motion of magnet with respect to coil or vice-versa, changes the magnetic field. Due to this change in magnetic field lines, potential difference is induced in the same coil, which set up an induced current in the circuit.

(b) **SECOND EXPERIMENT - Mutual Induction**



In this experiment plug in the key that is connect coil with battery and observe the deflection in galvanometer. Now plug out the key that is disconnect the coil-1 from battery and observe the deflection in galvanometer, which will be in reverse direction.

Hence, we conclude that potential difference is induced in secondary coil (coil-2), whenever there is a change in current, in primary coil (coil-1) (by on and off of key).

This is because, whenever there is change in current in primary coil

↓

Magnetic field associated with it also changes

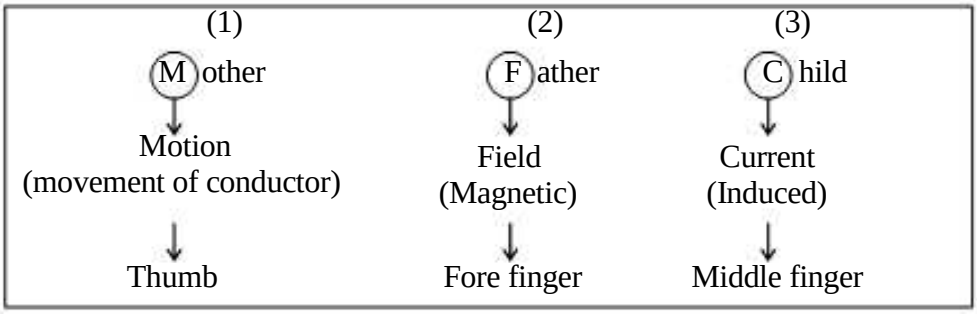
↓

Now, magnetic field lines around the secondary coil (coil-2) will change and induces the electric current in it (observed by the deflectionof needle of Galvanometer in secondary circuit)

This process, by which changing of strength of current in primary coil, induces a current in secondary coil is called Electromagnetic Induction"

The induced current is found to be highest when the direction of motion of coil is at right angles to the magnetic field.

19. **Fleming's Right Hand Rule**

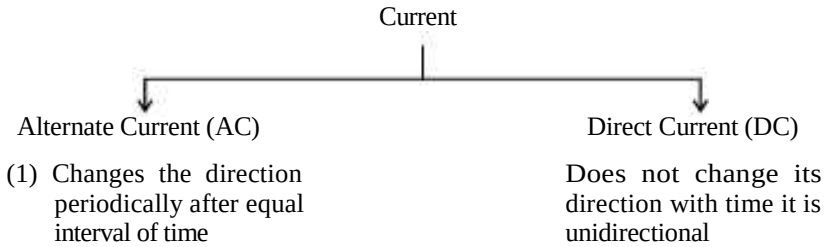


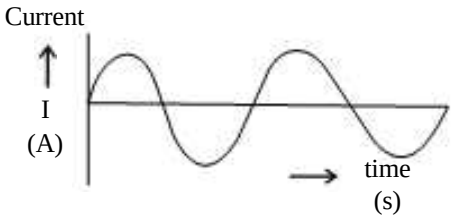
Three of them perpendicular to each other.

Rule can be defined at-

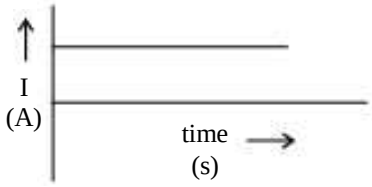
Stretch thumb, forefinger and middle finger of right hand, so that they are perpendicular to each other. The forefinger indicates direction of magnetic field, thumb shows the direction of motion of conductor, then the middle finger will shows the direction of induced current.

Electrical generator is based on the principle of electro magnetic induction. It convert mechanical energy into electrical energy.





It has frequency
50Hz in India
60 Hz in America



It has frequency
OHz

21. **Advantages of Alternate Current (AC) over Direct Current (DC)**

Electric power can be transmitted to longer distances without much loss of energy. Therefore cost of transmission is low.

In India the frequency of AC is 50Hz. It means after every 1/100 second it changes its direction.

22. **Domestic Electric Circuits :-**

In our homes, the electric power supplied is of potential difference V = 220V and frequency 50Hz.

It consist of three wires :-

(1) Wire with red insulation cover - LIVE WIRE (POSITIVE)

Live wire is at high potential of 220V

(2) Wire with black insulation cover - NEUTRAL WIRE (NEGATIVE)

Neutral wire is at zero potential

Therefore, the potential difference between the two is 220V.

(3) Wire with Green insulation cover - EARTH WIRE

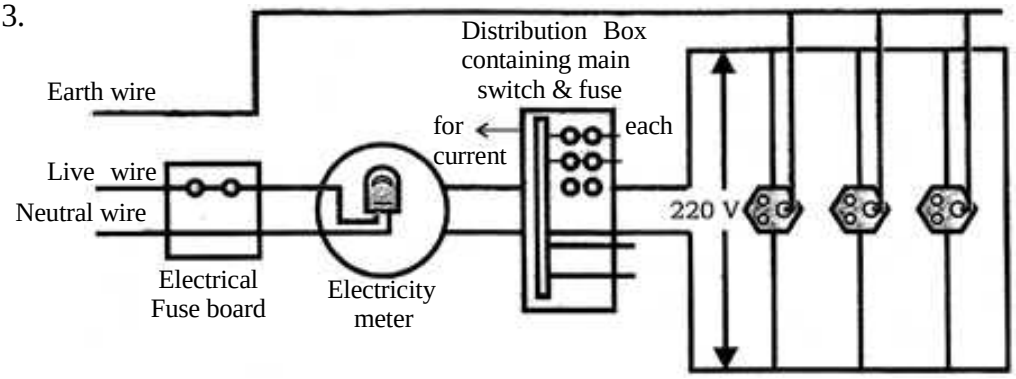
it is connected to a copper plate deep in the earth near house.

The metallic body of the appliances is connected with the earth wire as a safety measure.

Function-

Earth wire provide a low resistance to the current hence any leakage of current to the metallic body of the appliances, keep its potential equal to that of earth. That means zero potential and the user is saved from severe electric shock.

23.



Point to be noted in domestic circuit

(1) Each appliance has a seperate switch of ON/OFF

(2) In order to provide equal potential difference to each appliance, they should be connected parallel to each other. So that they can be operated at any time.

(3) We have two electric circuit in our home
- One consist of current of 15A for high power appliances
- Other circuit consist of current 5A for low power appliances.

24. **Short Circuiting -**

Due to fault in the appliances or damage in the insulation of two wires, the circuit will offer zero or negligible resistance to the flow of current. Due to low resistance, large amount of current will flow.

According to Joule's law of heating effect ($H \quad I^2$) heat is produced in live wire and produces spark, damaging the device and wiring.

25. **Overloading-**

Overloading can be caused by (1) Connecting too many appliances to a single socket or (2) accidental rise in supply voltage if the total current drawn by the appliances at a particular time exceeds the bearing capacity of that wire, it will get heated up. This is known as overloading.

Fuse a safety device can prevent the circuit from overloading and short circuiting.

EXERCISE

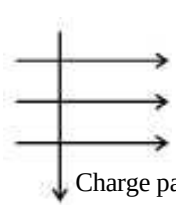
(Question Bank)

Very Short Answers (1 Mark)

1. What is the frequency of AC used in India?
2. Name the point where the iron filling are collected more?
3. Who discovered electro magnetic induction?
4. Why does a compass needle get deflected when brought near the bar magnet?
5. If both the coil and the magnet are stationary, will there be deflection in galvanometer?
6. Why magnetic field lines do not intersect each other?
7. What is the advantage of Alternate Current over Direct current?
8. What do you understand by short circuiting?
9. When the force experienced by a current carrying conductor placed in a magnetic field is maximum?
10. Write the factors affecting the magnetic field due to a straight conductor?

Short Answers (2 Marks)

1. A charged particles enters at right angles into a uniform magnetic field. What is the nature of charge particle, if it experiences a force in a direction pointing vertically out of the page.



(use left hand flemings rule)

2. Name the Rule-
   (1) Force experience by a current - carrying conductor placed in a magnetic field.
   (2) Direction of magnetic field lines associated with a current carrying conductor.
   (3) Direction of induced current in a coil due to its rotation in magnetic field.

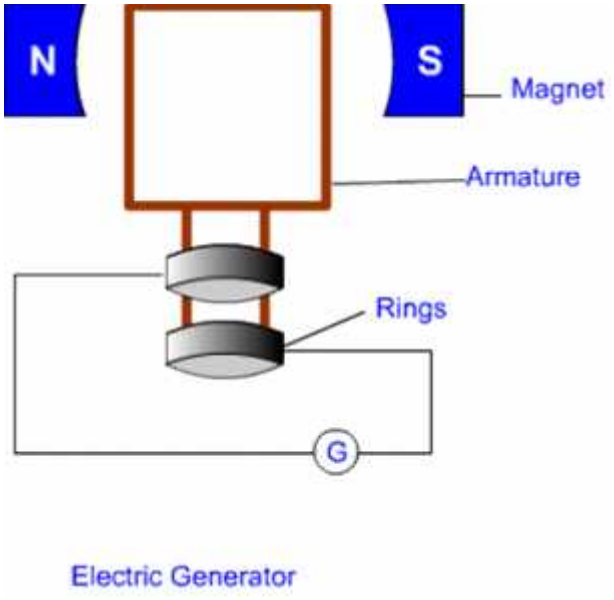
3. What is solenoid? Where the magnetic field is uniform in solenoid?
4. Draw the pattern of magnetic field lines due to current carrying straight conductor?
5. Name two safety measures commonly used in electric circuit and appliances?
6 What is overloading?

Long Answer (5 Marks)

1. Explain the phenomenon of Electro magnetic Induction with the help of an activity. Write its one application.
2. Draw the schematic diagram of domestic circuit. Write the colour and function of Neutral wire, Live wire and Earth wire.

➢ **Explain the underlying principle and working of an electric generator by drawing a labelled diagram. What is the function of brushes?**

Answer: The structure of electric generator is similar to that of an electric motor. In case of an electric generator a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in way that it can move around an axle. When the armature moves within the magnetic field an electric current is induced



Electric Generator

The direction of induced current changes, when the armature crosses the halfway mark of its rotation. Thus, the direction of current changes once in every rotation. Due to this, the electric generator usually produces alternate current, i.e. AC.

To convert an AC generator into a DC generator, a split ring commutator is used. This helps in producing direct current

➢ **When does an electric short circuit occur?**

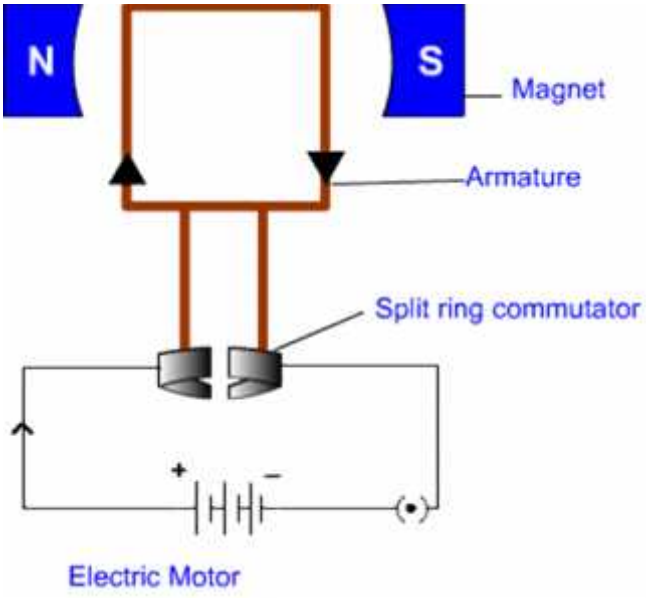
Answer: When positive and negative wires touch each other, the resistance suddenly decreases and current increases. This leads to excessive heating of wire which manifests in the form of sparks. This is called short circuit.

➢ **What is the function of an earth wire? Why is it necessary to earth metallic appliances?**

Answer: The earth wire transfers any leakage of electric current to the earth. The leaked current can otherwise reach the metallic body of an appliance and can lead to electric shock. Earth wire prevents from electric shock by safety transferring the leaked current to the earth

➢ **Draw a labelled diagram of an electric motor. Explain its principle and working. What is the function of a split ring in an electric motor?**

Answer: Working of Electric Motor: Electrical energy is converted into mechanical energy by using an electric motor. Electric motor works on the basis of rule suggested by Marie Ampere and Fleming's Left Hand Rule.



In an electric motor, a rectangular coil is suspended between the two poles of a magnetic field. The electric supply to the coil is connected with a commutator. Commutator is a device which reverses the direction of flow of electric current through a circuit.

When electric current is supplied to the coil of electric motor, it gets deflected because of magnetic field. As it reaches the half way, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of current reverses the direction of forces acting on the coil. The change in direction of force pushes the coil; and it moves another half turn. Thus, the coil completes one rotation around the axle. Continuation of this process keeps the motor in rotation.

In commercial motor, electromagnet; instead of permanent magnet; and armature is used. Armature is a soft iron core with large number of conducting wire turns over it. Large number of turns of conducting wire enhances the magnetic field produced by armature.

➢ **Name some devices in which electric motors are used.**

Answer: Electric fan, mixer grinder, tape recorder, CD player, hard disk drive, washing machine, cooler, toy car, vacuum cleaner, etc. are some devices in which electric motor is used.

➢ **A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) pushed into the coil, (ii) withdrawn from inside the coil, (iii) held stationary inside the coil?**

➢ **Answer:** When the bar magnet is pushed into the coil or withdrawn from the coil; the galvanometer needle would show deflection. When the bar magnet is kept stationary inside the coil; the galvanometer needle would show no deflection.

➢ **Two circular coils A and B are placed close to each other. If the current in the coil A is changed, will some current be induced in the coil B? Give reason.**

Answer: When two circular coils A and B are placed close to each other and the current in coil A is changed, it leads to induction of current in coil B. This happens because of change in magnetic field of coil A; because of change in current in this coil.

➢ **List three methods of producing magnetic fields.**

Answer: Three methods of producing magnetic fields are as follows:

- By permanent magnet
- By electromagnet
- By current carrying conductors

➢ **How does a solenoid behave like a magnet? Can you determine the north and south poles of a current–carrying solenoid with the help of a bar magnet? Explain.**

Answer: A solenoid begins behaving like a magnet when electric current flows through it. We know that any current carrying conductor creates a magnetic field around it and that is what happens in case of solenoid. For determining the different poles of a solenoid, we can use a bar magnet and look for interaction between different poles of two magnets. If the north pole of the bar magnet gets repulsed by a particular pole of the electromagnet (solenoid) then it gets confirmed that the bar magnet was brought near the north pole of the electromagnet.

➢ **When is the force experienced by a current–carrying conductor placed in a magnetic field largest?**

Answer: From Fleming's Left Hand Rule, it is clear that when the direction of current and magnetic field are in mutually perpendicular directions, the deflection in conductor is the maximum. This shows that when magnetic field and direction of current are perpendicular to each other, the force experienced by the conductor is the largest.

➢ **Imagine that you are sitting in a chamber with your back to one wall. An electron beam, moving horizontally from back wall towards the front wall, is deflected by a strong magnetic field to your right side. What is the direction of magnetic field?**

Answer: Here, the electron beam is moving towards the viewer, i.e. out of the plane of the page. This means that the direction of current is towards the page. This shows the direction in which the forefinger is pointing. The thumb is pointing towards right which is same as the direction of deflection. The middle finger is pointing downwards; which shows the direction of the magnetic field.