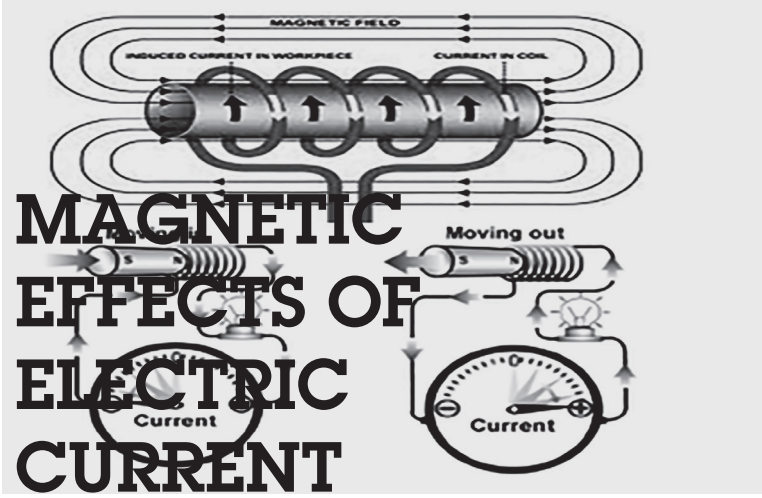
CHAPTER

# 13

# MAGNETIC EFFECTS OF ELECTRIC CURRENT




## Chapter Objectives

This chapter will help you to understand :

- ***Magnetism and magnetic field :*** *Definition; Magnetic fields and magnetic lines; magnetic field due to current carrying conductor- straight conductor, circular loop, solenoid; Force on a current carrying conductor in a magnetic field; Electric motor.*
- ***Electro-magnetic induction :*** *Definition; Electric generator; and Domestic electric circuit.*

## TOPIC-1
## Magnetism and Magnetic Field



### Quick Review

- Magnets were first discovered around 4,000 years ago when a shepherd named **magnes** got the nails in the sole of his shoe stuck to a magnetic rock, later called **magnetite**.
- Most materials can be classified as **diamagnetic**, **paramagnetic** and **ferromagnetic**.
- **Diamagnetic** materials have a weak, negative susceptibility to magnetic fields. Diamagnetic materials are slightly repelled by a magnetic field and the material does not retain the magnetic properties when the external field is removed.
- **Paramagnetic** materials have a small, positive susceptibility to magnetic fields. These materials are slightly attracted by a magnetic field and the material does not retain the magnetic properties when the external field is removed.
- **Ferromagnetic** materials have a large, positive susceptibility to an external magnetic field. They exhibit a strong attraction to magnetic fields and are able to retain their magnetic properties after the external field has been removed.
- **Biot-Savart's law**, in physics, a fundamental quantitative relationship between an electric current and the magnetic field it produces, based on the experiments in 1820 of the French scientists **Jean-Baptiste Biot and Félix Savart**.
- **Biot-Savart Law :** An equation that describes the magnetic field generated by an electric current. It relates the magnetic field to the magnitude, direction, length, and proximity of the electric current. The law is valid in the magneto-static approximation and is consistent with both Ampère's circuital law and Gauss's law for magnetism.
- **Ampere's Law :** An equation that relates magnetic fields to electric currents that produce them. Using Ampere's law, one can determine the magnetic field associated with a given current or current associated with a given magnetic field, providing there is no time changing electric field present.

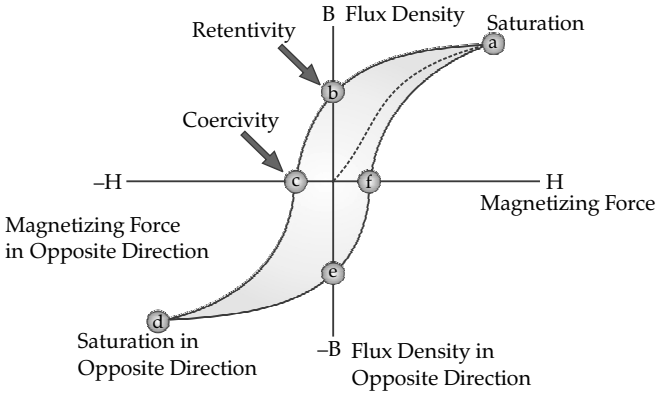
**TIPS...**

- *Study the history of Electro-magnetism.*
- *Understand the directions with the help of Fleming's left-hand rule and right-hand rule.*
- *Study the force exerted by Magnetic field on current carrying conductor.*
- *Recall the working principle of Electric motor.*

**TRICKS...**

- *Practice the diagram of Electric motor.*
- *Make flow chart to remember the Flemings' rules.*

- A **hysteresis loop** shows the relationship between the induced magnetic flux density (B) and the magnetising force (H). It is often referred to as the **B-H loop**.
- The loop is generated by measuring the magnetic flux of a ferromagnetic material while the magnetising force is changed.
- **The Law of Conservation of Charge :** The net charge of an isolated system remains constant. The only way to change the net charge of a system is to bring in charge from elsewhere or remove charge from the system. Charge can be created and destroyed, but only in positive-negative pairs.




## Know the Links

- *https://www.encyclopedia.com/science-and-technology/physics/physics/electricity-and-magnetism*
- *http://www.nde-ed.org/EducationResources/CommunityCollege/MagParticle/Physics/HysteresisLoop.htm*
- *https://courses.lumenlearning.com/boundless-physics/chapter/magnetism-and-magnetic-fields/*

## Multiple Choice Questions **(1 mark each)**

**Q. 1. Choose the incorrect statement from the following regarding magnetic lines of field :**

**(a) The direction of magnetic field at a point is taken to be the direction in which the north pole of a magnetic compass needle points.**

**(b) Magnetic field lines are closed curves.**

**(c) If magnetic field lines are parallel and equidistant, they represent zero field strength.**

**(d) Relative strength of magnetic field is shown by the degree of closeness of the field lines.**

**[NCERT Exemp. Q. 1, Page 97]**

**Ans. Correct option :** (c)

*Explanation :* Magnetic field lines appear parallel when they are far from the magnet. But this does not mean that field strength is zero. No field line would be present where field strength becomes zero.

**Q. 2. 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.**

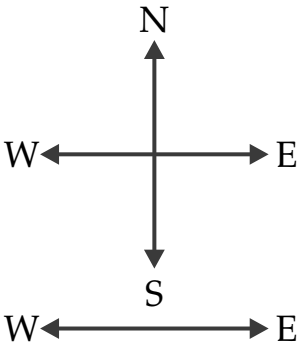
**(c) The field consists of radial lines originating from the wire.**

**(d) The field consists of concentric circles centered on the wire.** **[NCERT Ex. Q. 1, Page 240]**

**Ans. Correct option :** (d)

*Explanation :* The field consists of concentric circles centered on the wire. On applying right-hand thumb rule, we find the direction of magnetic field. The field is in the form of concentric circles centered on the wire carrying current.

**Q. 3. A constant current flow in a horizontal wire in the plane of the paper from East to West is shown in Figure. The direction of magnetic field at a point will be North to South :**




**(a) directly above the wire.**

**(b) directly below the wire.**

**(c) at a point located in the plane of the paper, on the north side of the wire.**

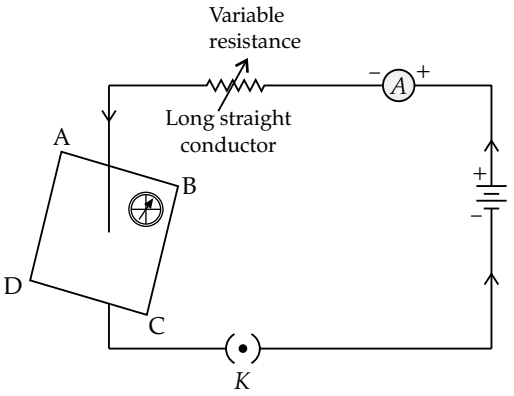
**(d) at a point located in the plane of the paper, on the south side of the wire.**

**[NCERT Exemp. Q. 9, Page 99]**

**Ans. Correct option :** (b)

*Explanation :* Line WE show a straight conductor through which current is moving from E to W. When seen from east, the magnetic field lines appear in clockwise direction, *i.e.* S to N above the wire and N to S below the wire. This is in accordance with Right Hand Thumb rule.

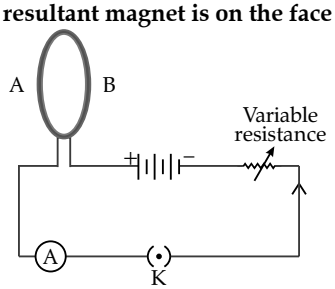
**Q. 4. If the key in the arrangement in the given Figure, is taken out (the circuit is made open) and magnetic field lines are drawn over the horizontal plane ABCD, the lines are :**




**(a) concentric circles.**
**(b) elliptical in shape.**
**(c) straight lines parallel to each other.**
**(d) concentric circles near the point O but of elliptical shapes as we go away from it.**
**[NCERT Exemp. Q. 2, Page 97]**

**Ans. Correct option :** (a)
***Explanation :*** Magnetic field lines around a straight current carrying conductor are in the form of concentric circles.

**Q. 5. A circular loop placed in a plane perpendicular to the plane of paper carries a current when the key is ON. The current as seen from points A and B (in the plane of paper and on the axis of the coil) is anti-clockwise and clockwise respectively. The magnetic field lines point from B to A. The N-pole of the resultant magnet is on the face close to :**




**(a) A.**
**(b) B.**
**(c) A, if the current is small, and B if the current is large.**
**(d) B, if the current is small and A if the current is large. [NCERT Exemp. Q. 3, Page 97]**

**Ans. Correct option :** (a)
***Explanation :*** Magnetic field lines are in the direction from South Pole to North Pole. Point A is showing North Pole because field lines are pointing from B to A.

**Q. 6. For a current in a long straight solenoid N- and S-poles are created at the two ends. Among the following statements, the incorrect statement is :**
**(a) The field lines inside the solenoid are in the form of straight lines which indicates that the magnetic field is the same at all points inside the solenoid.**
**(b) The strong magnetic field produced inside the solenoid can be used to magnetise a piece of magnetic material like soft iron, when placed inside the coil.**
**(c) The pattern of the magnetic field associated with the solenoid is different from the pattern of the magnetic field around a bar magnet.**
**(d) The N and S-poles exchange position when the direction of current through the solenoid is reversed. [NCERT Exemp. Q .4, Page 98]**

**Ans. Correct option :** (c)
***Explanation :*** A solenoid behaves like a bar magnet. Hence, the pattern of the magnetic field associated with the solenoid is same as the pattern of the magnetic field around a bar magnet.

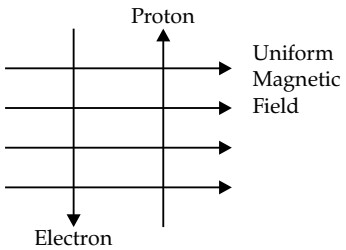
**Q. 7. The strength of magnetic field inside a long current carrying straight solenoid is :**
**(a) more at the ends than at the centre**
**(b) minimum in the middle**
**(c) same at all points**
**(d) found to increase from one end to the other**
**[NCERT Exemp. Q. 10, Page 99]**

**Ans. Correct option :** (c)
***Explanation :*** Magnetic field lines are straight and parallel inside the solenoid. This indicates a strong magnetic field. Hence, inside the solenoid, the magnetic field is same throughout.

**Q. 8. Choose the correct option.**
**The magnetic field inside a long straight solenoid-carrying current :**
**(a) is zero.**
**(b) decreases as we move towards its end.**
**(c) increases as we move towards its end.**
**(d) is the same at all points. [NCERT Q. 3, Page 230]**

**Ans. Correct option :** (d)
***Explanation :*** The magnetic field inside a long straight current-carrying solenoid is uniform which is represented by parallel lines. Hence it is same at all points.

**Q. 9. A uniform magnetic field exists in the plane of paper pointing from left to right as shown in Figure. In the field an electron and a proton move as shown. The electron and the proton experience :**




**(a) forces both pointing into the plane of paper.**
**(b) forces both pointing out of the plane of paper.**
**(c) forces pointing into the plane of paper and out of the plane of paper, respectively.**
**(d) forces pointing opposite and along the direction of the uniform magnetic field, respectively.**
**[NCERT Exemp. Q. 5, Page 98]**

**Ans.** Correct option : (a)
***Explanation :*** Direction of current is opposite to the direction of movement of electron. So, current will move upwards. If index finger is showing the direction of magnetic field, ring finger is showing

the direction of current, then direction of thumb is into the paper.

**Q. 10. Which of the following property of a proton can change while it moves freely in a magnetic field? (There may be more than one correct answer.)**

**(a) Mass** **(b) Speed**
**(c) Velocity** **(d) Momentum**

**[NCERT Q. 1, Page 231]**

**Ans. Correct option :** (c) and (d)

*Explanation :* When a proton enters a magnetic field, it starts moving on a circular path. Because of its movement along a circular path it attains angular momentum. We know that momentum is a product of mass and velocity. Therefore velocity and mass of a proton change when it enters a magnetic field.

**Q. 11. A positively-charged particle (alpha-particle) projected towards west is deflected towards north by a magnetic field. The direction of magnetic field is**

**(a) towards south.** **(b) towards east.**
**(c) downward.** **(d) upward.**

**[NCERT Q. 3, Page 232]**

**Ans. Correct option :** (d)

*Explanation :* In accordance with Fleming's Left-Hand Rule, the direction of magnetic field is vertically upward.

**Q. 12. Commercial electric motors do not use**

**(a) an electro-magnet to rotate the armature.**
**(b) effectively large number of turns of conducting wire in the current carrying coil.**
**(c) a permanent magnet to rotate the armature.**
**(d) a soft iron core on which the coil is wound.**

**[NCERT Exemp. Q. 6, Page 98]**

**Ans. Correct option :** (c)

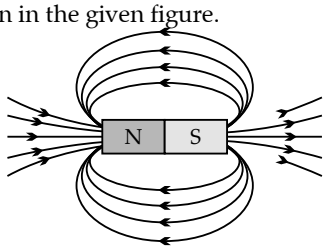
*Explanation :* Electro-magnet is used instead of permanent magnet in commercial electric motor.

## Very Short Answer Type Questions (1 or 2 marks each)

**Q. 1. Draw magnetic field lines around a bar magnet.**

**[NCERT Q. 1, Page 228]**

**Ans.** Magnetic field lines of a bar magnet emerge from the North Pole and terminate at the South Pole. Inside the magnet, the field lines emerge from the South Pole and terminate at the North Pole, as shown in the given figure. **[1]**




**[1]**

**Q. 2. List the properties of magnetic lines of force.**

**[NCERT Q. 2, Page 228]**

**Ans.** Properties of magnetic lines of force (also known as magnetic field lines) are listed below :

**(i)** Outside the magnet, the magnetic field lines are directed from N-pole of magnet towards S-pole. However, inside a magnet the field lines are directed from S-pole to N-pole. Thus, magnetic field lines form a close loop. **[½]**

**(ii)** The magnetic field line at any point points in the direction of magnetic field at that point. **[½]**

**(iii)** The relative strength of magnetic fields is given by degree of closeness of the field lines. The magnetic field is strong in the region where the field lines are crowded. **[½]**

**(iv)** No two magnetic field lines can ever intersect with each other. **[½]**

**Q. 3. Why don't two magnetic lines of force intersect each other? [NCERT Q.3, Page 228]**

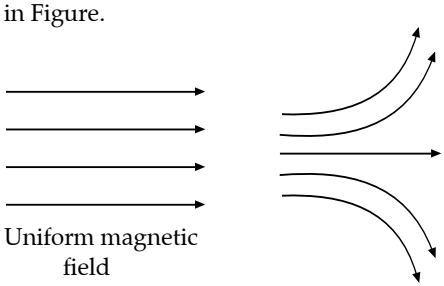
**Ans.** The two magnetic field lines can never intersect each other because two tangents can be drawn from that point of intersection which will give two directions of the field from the same point, which is impossible. **[1]**

So, the two magnetic field lines can never intersect each other. **[1]**

**Q. 4. The magnetic field in a given region is uniform. Draw a diagram to represent it.**

**[NCERT Q. 2, Page 229]**

**Ans.** The uniform magnetic field is represented by parallel, equidistant lines of equal length as shown in Figure. **[1]**



Uniform magnetic field

Non-uniform magnetic field **[1]**

**Q. 5. List two methods of producing magnetic fields.**

**[NCERT Ex. Q. 7, Page 240]**

**Ans.** Two methods of producing magnetic fields are as follows :

Magnetic field is produced around a current carrying straight conductor or a current carrying coil. **[1]**

A very good method to produce magnetic field is due to flow of current in a solenoid. **[1]**

**Q. 6. Why does a compass needle get deflected when brought near a bar magnet?**

**[NCERT Q. 1, Page 224]**

**Ans.** A compass needle is a small bar magnet. **[1]**

When it is brought near a bar magnet, its magnetic field lines interact with that of the bar magnet. Hence, a compass needle shows a deflection when brought near the bar magnet. **[1]**

**Q. 7. When is the force experienced by a current-carrying conductor placed in a magnetic field largest? [NCERT Ex. Q. 9, Page 241]**

**Ans.** The force experienced by a current-carrying conductor is largest when the directions of magnetic field and electric current are perpendicular to each other. **[2]**

**Q. 8. What is the principle of an electric motor?** **[NCERT Q. 2, Page 233]**

**Ans.** The principle of an electric motor is based on the magnetic effect of electric current. **[1]**

**Q. 9. A current-carrying loop experiences a force and rotates when placed in a magnetic field. The direction of rotation of the loop is according to the Fleming's Left-Hand Rule. [1]**

**Q. 10. What is the role of the split ring in an electric motor?** **[NCERT Q. 3, Page 233]**

**Ans.** The split ring in the electric motor acts as a commutator. The commutator reverses the direction of current flowing through the coil after each half rotation of the coil. **[1]**

Due to this reversal of the current, the coil continues to rotate in the same direction. **[1]**

**Q. 11. Name some devices in which electric motors are used.** **[NCERT Ex. Q. 12, Page 241]**

**Ans.** Electric motors are used in all such devices where we want to convert electrical energy into mechanical energy so as to drive that machine. **[1]**

Some devices in which electric motors are used are following :

**(i)** Water pumps
**(ii)** Electric fans
**(iii)** Electric mixers
**(iv)** Washing machines **[1]**

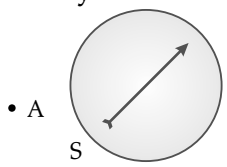
**Q. 12. What does the direction of thumb indicate in the right-hand thumb rule. In what way this rule is different from Fleming's left-hand rule?** **[NCERT Exemp. Q. 18, Page 100]**

**Ans.** The thumb indicates the direction of current in the straight conductor held by curled fingers, whereas the Fleming's left-hand rule gives the direction of force experienced by current carrying conductor placed in an external magnetic field. **[2]**

## Short Answer Type Questions

**(3 or 4 marks each)**

**Q. 1. A magnetic compass needle is placed in the plane of paper near point A as shown in Figure. In which plane should a straight current carrying conductor be placed so that it passes through A and there is no change in the deflection of the compass? Under what condition is the deflection maximum and why?**




**[NCERT Exemp. Q. 13, Page 100]**

**Ans.** In the plane of the paper itself. The axis of the compass is vertical and the field due to the conductor is also vertical. **[1]**

It could result in a dip of compass needle which is not possible in this case (dips result only if axis of compass is horizontal). **[1]**

The deflection is maximum when the conductor through A is perpendicular to the plane of paper and the field due to it is maximum in the plane of the paper. **[1]**

**Q. 2. 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.** **[NCERT Ex. Q. 15, Page 241]**

**Ans.** The rules to determine the direction are :

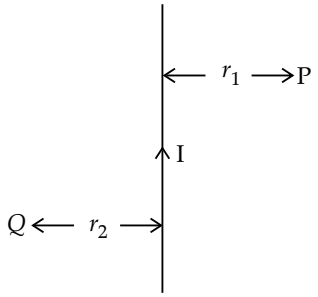
**(i)** Maxwell's right-hand thumb rule **[1]**
**(ii)** Fleming's left-hand rule **[1]**
**(iii)** Fleming's right-hand rule **[1]**

**Q. 3. A magnetic compass shows a deflection when placed near a current carrying wire. How will the deflection of the compass get affected if the current in the wire is increased? Support your answer with a reason.** **[NCERT Exemp. Q. 16, Page 100]**

**Ans.** The deflection increases. **[1]**

The strength of magnetic field is directly proportional to the magnitude of current passing through the straight conductor. **[2]**

**Q. 4. AB is a current carrying conductor in the plane of the paper as shown in Figure. What are the directions of magnetic fields produced by it at points P and Q? Given $r_1 > r_2$, where will the strength of the magnetic field be larger?**




**[NCERT Exemp. Q. 15, Page 100]**

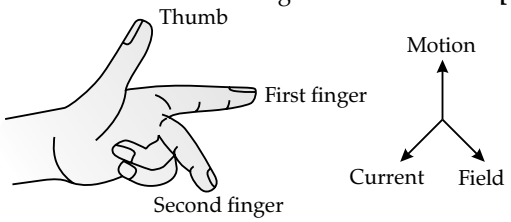
**Ans.** According to Right Hand Thumb Rule, if all fingers of right hand we wrapped in a fist and thumb shows the direction of electric current, then direction of wrapped fingers shows the direction of magnetic field. **[1½]**

In case of $r_1$, the direction of magnetic field is towards the paper. In case of $r_2$, the direction of magnetic field is out of the paper. Since $r_1 > r_2$, so strength of magnetic field at P is less than that at Q. **[1½]**

**Q. 5. State Fleming's left-hand rule.**
**[CBSE Board Delhi Region 2016]**
**[NCERT Q. 1, Page 233]**

**Ans.** According to Fleming's Left-Hand Rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. **[1]**

If the first finger points in the direction of magnetic field and the second finger in the direction of current, then the thumb will point in the direction of motion or the force acting on the conductor. **[1]**




**[1]**

**Q. 6. Meena draws magnetic field lines of field close to the axis of a current carrying circular loop. As she moves away from the centre of the circular loop she observes that the lines keep on diverging. How will you explain her observation?**
**[NCERT Exemp. Q. 19, Page 100]**

**Ans.** Strength of the magnetic field decreases as distance increases. **[1½]**

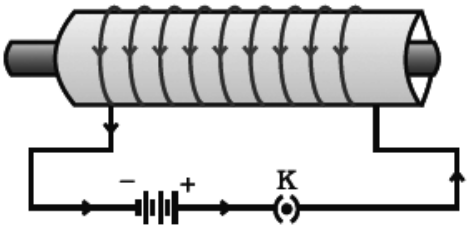
This is indicated by the decrease in degree of closeness of the lines of field. **[1½]**

**Q. 7. Under what conditions permanent electro-magnet is obtained if a current carrying solenoid is used? Support your answer with the help of a labelled circuit diagram. [NCERT Exemp. Q. 14, Page 100]**

**Ans.** Following conditions are necessary for making electro-magnet from a current carrying solenoid.

**(i)** Circuit should be closed. **[1]**

**(ii)** A core of soft iron should be used. **[1]**



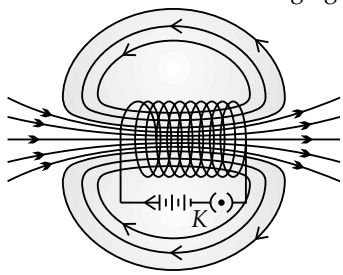

**[1]**

**Q. 8. What does the divergence of magnetic field lines near the ends of a current-carrying straight solenoid indicate?**
**[NCERT Exemp. Q. 20, Page 100]**

**Ans.** The divergence, that is, the falling degree of closeness of magnetic field lines indicates the fall in strength of magnetic field near and beyond the ends of the solenoid. **[2]**

**Q. 9. 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. [NCERT Ex. Q. 8, Page 241]**

**Ans.** Solenoid is coil having $n$ number of turns of insulated copper wire. Magnetic field lines are produced around the solenoid when a current is passed through it. The magnetic field produced by it is similar to the magnetic field of a bar magnet. The field lines produced in a current-carrying solenoid is shown in the following figure. **[1]**




**[1]**

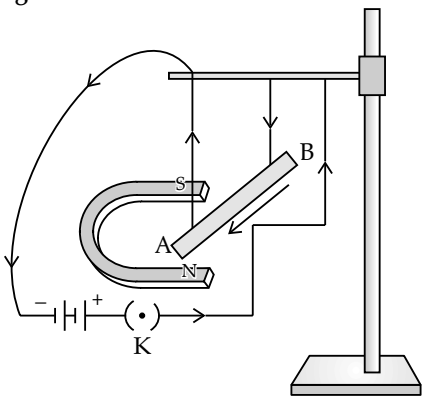
When the North Pole of a bar magnet is brought near to the end connected to the negative terminal of the battery, then the solenoid repels the bar magnet. It means the end of solenoid which is connected to the negative terminal of the battery behaves as North Pole as like poles repel each other similarly the other and behaves as a South Pole. **[1]**

**Q. 10. In Activity, how do we think the displacement of rod AB will be affected if**

**(i) current in rod AB is increased**

**(ii) a stronger horse-shoe magnet is used,**

**(iii) length of the rod AB is increased?**




**[NCERT Q. 2, Page 232]**

**Ans.** The displacement would vary directly as the strength of current, strength of magnetic field and length of the conductor. Due to this, the displacement of conductor would be increased in all the three cases.

**(i)** If current in rod AB is increased, the displacement will also increase. **[1]**

**(ii)** If we use a stronger horse-shoe magnet then the displacement of rod AB will increase. **[1]**

**(iii)** If length of the rod is increased, force acting on it will increase and, hence, displacement of the rod increases. **[1]**

**Q. 11. It is established that an electric current through a metallic conductor produces a magnetic field around it. Is there a similar magnetic field produced around a thin beam of moving :**

**(i) alpha particles,**

**(ii) neutrons? Justify your answer.**

**[NCERT Exemp. Q. 17, Page 100]**

**Ans.** **(i)** Yes, Alpha particles being positively charged constitute a current in the direction of motion. **[1½]**

**(ii)** No. The neutrons being electrically neutral constitute no current. **[1½]**

**Q. 12. 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? [NCERT Ex. Q. 10, Page 241]**

**Ans.** Recall that the direction of current is taken opposite to the direction of motion of electrons. **[1]**

The direction of current is from the front wall to the back wall because negatively charged electrons are moving from back wall to the front wall. **[1]**

The direction of magnetic force is rightward. Hence, using Flemings Left Hand Rule, it can be concluded that the direction of magnetic field inside the chamber is downward. **[1]**

**Q. 13. What is the role of the two conducting stationary brushes in a simple electric motor?**
**[NCERT Exemp. Q. 22, Page 100]**

**Ans.** The two stationary conducting brushes make the contact in between the two halves of the split rings and the source battery. **[1½]**

Current in the coil enters from the source battery through one conducting brush and flows back to the battery through another brush. **[1½]**

**Q. 14. Name four appliances wherein an electric motor, a rotating device that converts electrical energy to mechanical energy, is used as an important component. In what respect motors are different from generators? [NCERT Exemp. Q. 21, Page 100]**

**Ans.** Four appliances wherein an electric motor is used are :

Electric fans, mixers, washing machines and computer drives. **[1½]**

Motors convert electrical energy into mechanical energy whereas generators convert mechanical energy into electrical energy. **[1½]**

## Long Answer Type Questions

**(5 mark each)**

**Q. 1. Why does a magnetic compass needle pointing North and South in the absence of a nearby magnet gets deflected when a bar magnet or a current carrying loop is brought near it. Describe some salient features of magnetic lines of field concept. [NCERT Exemp. Q. 25, Page 101]**

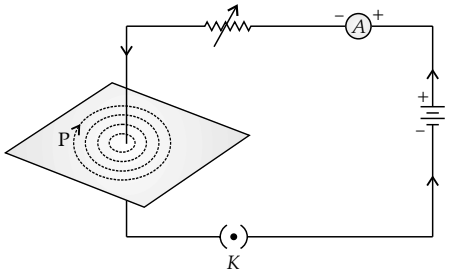
**Ans.** Current-carrying loops behave like bar magnets and both have their own magnetic field lines. This modifies the already existing Earth's magnetic field and a deflection results. Magnetic field has both direction and magnitude. Magnetic field lines emerge from N-pole and enter S-pole. The magnetic field strength is represented diagrammatically by the degree of closeness of the field lines. **[2½]**

Field lines cannot cross each other as two values of net field at a single point cannot exist. Only one value, a unique net value, can exist. If in a given region, lines of field are shown to be parallel and equi-spaced, the field is understood to be uniform. **[2½]**

**Q. 2. With the help of a labelled circuit diagram illustrate the pattern of field lines of the magnetic field around a current carrying straight long conducting wire. How is the right-hand thumb rule useful to find direction of magnetic field associated with a current carrying conductor?**
**[NCERT Exemp. Q. 26, Page 101]**

**Ans.** **Magnetic field around a current carrying straight long conducting wire :**

The magnetic field lines around a straight conductor (straight wire) carrying current are concentric circles whose centres lie on the wire. **[1]**




**[2]**

**Right Hand Thumb Rule :**

Right Hand Thumb Rule states that if a current-carrying straight conductor is supposedly held in the right hand with the thumb pointing towards the direction of current, then the fingers will wrap around the conductor in the direction of the field lines of the magnetic field. **[1]**

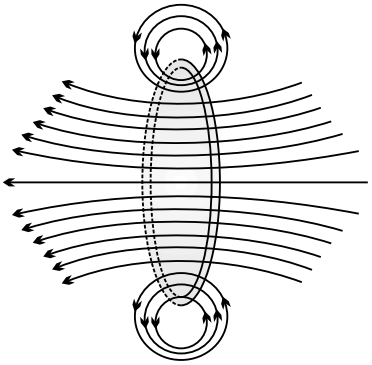
Using the right-hand thumb rule, if we point thumb down wards in the direction of the current, the magnetic field would be represented by the curled fingers as the circles around the conductor. So, if it is viewed from the above plane this field lines will be clockwise circles, but the direction of the magnetic field at any point on this circular magnetic line is in the direction of the tangent drawn to the circular magnetic lines at the desired points. **[1]**

**Q. 3. Explain with the help of a labelled diagram the distribution of magnetic field due to a current through a circular loop. Why is it that if a current carrying coil has *n* turns the field produced at any point is *n* times as large as that produced by a single turn? [NCERT Exemp. Q. 27, Page 101]**

**Ans.** In a current-carrying circular loop also the Right-Hand Thumb Rule is being obeyed. This means magnetic field lines are around the conducting wire. But circular shape of the conductor means that field lines at different points of the loop appear

to be making ring around the periphery of the loop. It can be visualized like many small rings looping around the periphery of a big ring. **[2]**

Effect of number of turns in a coil : If number of turns in coil is increased, then magnetic field also increases. Due to this, strength of magnetic field increases with increased number of turns in a coil. **[1]**



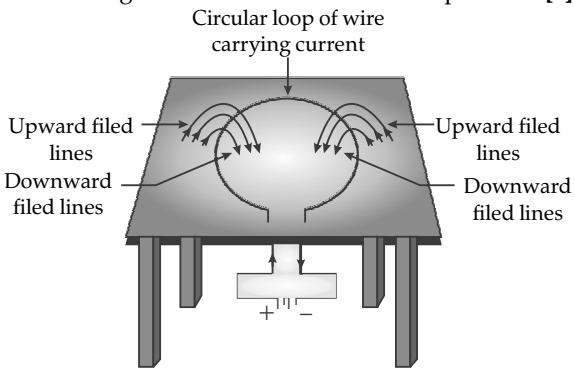
**[2]**

**Q. 4. Consider a circular loop of wire lying in the plane of the table. Let the current pass through the loop clockwise. Apply the right-hand rule to find out the direction of the magnetic field inside and outside the loop. [NCERT Q. 1, Page 229]**

**Ans.** According to the right-hand thumb rule :

If you are holding a current-carrying straight conductor in your right hand such that the thumb points towards the direction of the current. Then, your fingers will wrap around the conductor in the direction of the field lines of the magnetic field. **[1]**

In this case, consider that a circular loop of wire is lying on the plane of the table as shown. Let the current pass through the loop in the clockwise direction. On applying the right-hand thumb rule to the right side and left side of the loop : **[1]**




**[1]**

**For the right side of the circular loop :**

The direction of magnetic field lines will be as if they are emerging from the table outside the loop and while they will be going into the table inside the loop as shown in the figure. **[1]**

**Similarly, for the left side of the circular loop :**

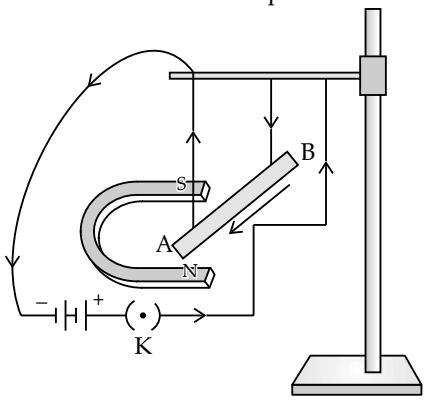
The direction of magnetic field lines inside the loop will also be going into the table while outside the loop they will be emerging from the table as shown. **[1]**

**Q. 5. Describe the activity that shows that a current-carrying conductor experiences a force perpendicular to its length and the external magnetic field. How does Fleming's left-hand rule help us to find the direction of the force acting on the current carrying conductor?**

**[NCERT Exemp. Q. 28, Page 101]**

**Ans.** Take a small rod (AB) of aluminium and suspend it with a stand; using two connecting wires.

**(i)** Take a horse-shoe magnet and keep it in a way that its magnetic field is in upward direction. For this, the North Pole should be at the bottom and South Pole should be at the top. The aluminium rod should be between the two poles of this magnet.




**[1]**

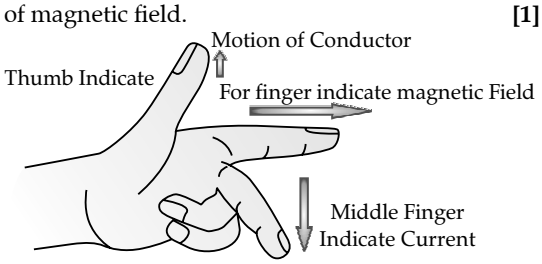
**(ii)** Now connect the aluminium rod to a battery and plug key so that current flows through it from B to A.

**(iii)** You will notice that the aluminium rod moves towards left.

**(iv)** Now, change the direction of current from A to B.

**(v)** In this case, the aluminium rod moves towards right.

In this experiment, direction of current and direction of magnetic field are mutually perpendicular. Direction of movement of aluminium rod is perpendicular to direction of current and direction of magnetic field. **[1]**




**[1]**

**Fleming's left-hand rule :** If the thumb, index finger and ring finger of left hand are kept in mutually perpendicular direction then index finger shows the direction of magnetic field, ring finger shows the direction of electric current and thumb shows the direction of deflection in current carrying conductor. By using this rule, we can easily find the direction of deflection. **[2]**

**Q. 6. Draw a labelled circuit diagram of a simple electric motor and explain its working. In what way these simple electric motors are different from commercial motors?**

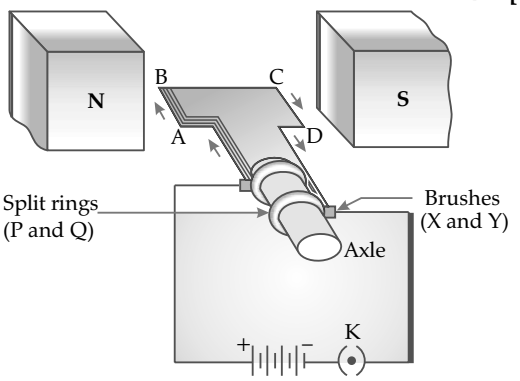
**[NCERT Exemp. Q. 29, Page 101]**

**Ans.** ABCD is a coil which is placed between the two poles of a permanent magnet. The coil is placed in such a way that the direction of current is perpendicular to the direction of magnetic field.

**(i)** Arms of the coil are attached to a split ring; which has two halves P and Q. Arms AB is attached to the half P, and arm CD is attached to the half Q.

**(ii)** The split rings are touching two static brushes X and Y from which they get electricity supply. The split rings are insulated from inside. An axle is passing through the split rings.

**(iii)** A battery supplies electric current to the coil. The flow of current is from A to B and from C to D. **[1]**




**[1]**

**Working of electric motor :**

Obeying Fleming's left-hand rule, when current passes from A to B; the arm AB of coil moves down. On the contrary, when current passes from C to D; the arm CD moves up. When the coil makes half a turn, P of split ring touches brush Y and its opposite happens with Q of split ring. As a result, the direction of current gets reversed. This means current now flows from D to C and from B to A. This pushes CD down and AB up. As a result, the coil turns continuously. **[1]**

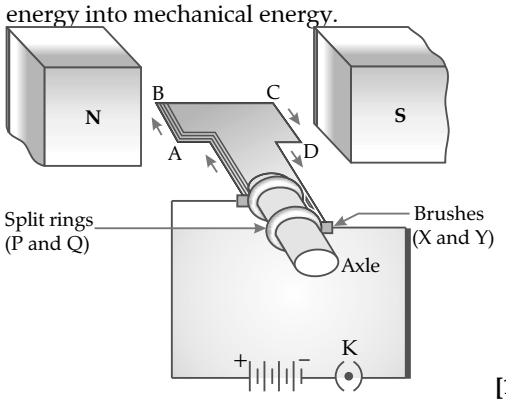
| Simple electric motor | Commercial electric motor |
|---|---|
| Permanent magnet is used. | Electro-magnet is used. |
| Number of turns in coil is less. | Large number of turns is present in coil. |
| Soft iron core is not used. | Coil is wound around a soft iron core to increase the power of the motor. |

**[2]**

**Q. 7. 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?**

**[NCERT Ex. Q. 11, Page 241]**

**Ans.** An electric motor is a device that converts electrical energy into mechanical energy.




**[1½]**

**Principle :** A current-carrying conductor, when placed in a magnetic field, experiences a force. If the direction of the field and that of the current are mutually perpendicular then force acting on the conductor will be perpendicular to both and will be given by Fleming's left-hand rule. Due to this force the conductor begins to move. **[1]**

**Working :** Refer Ans. 6. LA Type Question.

**Functin of split ring :** The split ring commutator is used to reverse the directioin of the current in the coil.

# TOPIC-2
## Electro-magnetic Induction

### Quick Review

- The more generalized equation is one of **Maxwell's equations**, called the **Maxwell-Faraday equation**, which defines the relationship between changes in electrical fields and magnetic fields.
- **Lenz's law** is named after the **German scientist H.F.E. Lenz** in **1834**. Lenz's law obeys Newton's third law of motion (*i.e.*, to every action there is always an equal and opposite reaction) and the conservation of energy (*i.e.*, energy may neither be created nor destroyed, and therefore, the sum of all the energies in the system is a constant).

**TIPS...**

- *Study and understand the basic concept of Electro-magnetic induction.*
- *Understand the Fleming's left-hand rule and right-hand rule.*

**TRICKS...**

- *Practice the diagram of Electric generator.*
- *Make flow chart to remember all important topics.*

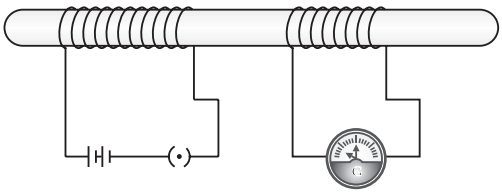
- ❖ Lenz's law states that an induced electric current flow in a direction such that the current opposes the change that induced it.
- ❖ The connection between electrical appliances and devices with the Earth plate or electrode through a thick wire of low resistance to provide safety is known as **'Earthing.'**

## Know the Links

- ☞ *https://www.studyrankers.com/2017/08/notes-of-ch-11-human-eye-and-colourful-class-10th.html*
- ☞ *http://www.dronstudy.com/book/human-eye-and-the-colourful-world-chapter-notes/*
- ☞ *http://www.hko.gov.hk/m/article_e.htm?title=ele_00493*

## Multiple Choice Questions **(1 mark each)**

**Q. 1. In the arrangement shown in Figure, there are two coils wound on a non-conducting cylindrical rod. Initially the key is not inserted. Then the key is inserted and later removed. Then**



**(a) the deflection in the galvanometer remains zero throughout.**
**(b) there is a momentary deflection in the galvanometer but it dies out shortly and there is no effect when the key is removed.**
**(c) there are momentary galvanometer deflections that die out shortly; the deflections are in the same direction.**
**(d) there are momentary galvanometer deflections that die out shortly; the deflections are in opposite directions. [NCERT Exemp. Q. 7, Page 98]**

**Ans. Correct option :** (d)
***Explanation :*** When key is plugged, galvanometer shows momentary deflection in one direction. When the key is removed, galvanometer shows momentary deflection in opposite direction.

**Q. 2. The phenomenon of electro-magnetic induction is**
**(a) the process of charging a body.**
**(b) the process of generating magnetic field due to a current passing through a coil.**
**(c) producing induced current in a coil due to relative motion between a magnet and the coil.**
**(d) the process of rotating a coil of an electric motor. [NCERT Ex. Q. 2, Page 240]**

**Ans. Correct option :** (c)
***Explanation :*** In electro-magnetic induction phenomenon, an induced current begins to flow in a coil whenever there is change in magnetic field in and around a coil.

**Q. 3. The device used for producing electric current is called a**
**(a) generator.** **(b) galvanometer.**
**(c) ammeter.** **(d) motor.**
**[NCERT Ex. Q. 3, Page 240]**

**Ans. Correct option :** (a)
***Explanation :*** An A.C. generator is the device used for producing an electric current.

**Q. 4. The essential difference between an AC generator and a DC generator is that**
**(a) AC generator has an electro-magnet while a DC generator has permanent magnet.**
**(b) DC generator will generate a higher voltage.**
**(c) AC generator will generate a higher voltage.**
**(d) AC generator has slip rings while the DC generator has a commutator. [NCERT Ex. Q. 4, Page 240]**

**Ans. Correct option :** (d)
***Explanation :*** AC generator has slip rings while the DC generator has a commutator.

**Q. 5. Choose the correct option.**
**A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each**
**(a) two revolutions.**
**(b) one revolution.**
**(c) half revolution.**
**(d) one-fourth revolution. [NCERT Q. 4, Page 237]**

**Ans. Correct option :** (c)
***Explanation :*** When a rectangular coil of copper wire is rotated in a magnetic field, the direction of the induced current changes once in each half revolution.

**Q. 6. To convert an AC generator into DC generator :**
**(a) split-ring type commutator must be used.**
**(b) slip rings and brushes must be used.**
**(c) a stronger magnetic field has to be used.**
**(d) a rectangular wire loop has to be used. [NCERT Exemp. Q. 11, Page 99]**

**Ans. Correct option :** (a)
***Explanation :*** Split ring commutator reverses the direction of current after each half turn of armature. This maintains a DC current.

**Q. 7. Choose the incorrect statement :**
**(a) Fleming's right-hand rule is a simple rule to know the direction of induced current.**
**(b) The right-hand thumb rule is used to find the direction of magnetic fields due to current-carrying conductors.**
**(c) The difference between the direct and alternating currents is that the direct current always flows in one direction, whereas the alternating current reverses its direction periodically.**

**(d) In India, the AC changes direction after every 1/50 second. [NCERT Exemp. Q. 8, Page 99]**

**Ans. Correct option :** (d)

*Explanation :* In India, the AC changes direction after every 1/100 second.

**Q. 8. At the time of short circuit, the current in the circuit :**

**(a) reduces substantially. (b) does not change.**

**(c) increases heavily. (d) vary continuously.**

**[NCERT Ex. Q. 5, Page 240]**

**Ans. Correct option :** (c)

*Explanation :* At the time of short circuiting the live wire and the neutral wire come into direct contact. As a result, the current in the circuit abruptly increases.

**Q. 9. The most important safety method used for protecting home appliances from short circuiting or overloading is :**

**(a) Earthing. (b) use of fuse.**

**(c) use of stabilisers. (d) use of electric meter.**

**[NCERT Exemp. Q. 12, Page 99]**

**Ans. Correct option :** (b)

*Explanation :* A fuse is a short length of wire designed to melt and separate in the event of excessive current to provide overloading.

**Q. 10. State whether the following statements are true or false :**

**(a) An electric motor converts mechanical energy into electrical energy.**

**(b) An electric generator works on the principle of electro-magnetic induction.**

**(c) The field at the centre of a long circular coil carrying current will be parallel straight lines.**

**(d) A wire with a green insulation is usually the live wire of an electric supply. [NCERT Ex. Q. 6, Page 240]**

**Ans. (a) False.** An electric motor converts mechanical energy into electrical energy.

**(b) True.** An electric generator works on the principle of electro-magnetic induction.

**(c) True.** The field at the centre of a long circular coil carrying current will be parallel straight lines.

**(d) False.** Live wire has red insulation cover, whereas Earth wire has green insulation colour in domestic circuits.

## Very Short Answer Type Questions (1 or 2 marks each)

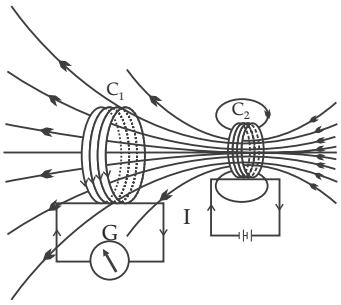
**Q. 1. Explain different ways to induce current in a coil. [NCERT Q. 1, Page 236]**

**Ans.** Different ways to induce current in a coil are as follows :

**(i)** If a magnetic field is changed around a coil then an induced current is set up in the coil. It can be done by taking a bar magnet and bringing it closer to the coil or taking it away from the coil.

**(ii)** If a coil is moved in a magnetic field, then again, an induced current is set up in the coil.

**(iii)** If a coil is rotated in a uniform magnetic field, it may also produce an induced current in the coil. **[1]**




**[1]**

**Q. 2. State the principle of an electric generator. [NCERT Q. 1, Page 237]**

**Ans.** An electric generator is based on the principle of electro-magnetic induction. **[1]**

When a rectangular coil is rotated in a uniform magnetic field, an induced voltage is generated between the ends of the coil. **[1]**

**Q. 3. Name some sources of direct current. [NCERT Q. 2, Page 237]**

**Ans.** Some sources of direct current are a cell, a battery and a D.C. generator. **[2]**

**Q. 4. Which sources produce alternating current? [NCERT Q. 3, Page 237]**

**Ans.** A.C. generator and invertors (used in house for emergency power supply) produces alternating current. **[2]**

**Q. 5. What is the function of an earth wire? Why is it necessary to earth metallic appliances? [NCERT Ex. Q. 18, Page 241]**

**Ans.** The metallic body of electric appliances is connected to the Earth by means of earth wire so that any leakage of electric current is transferred to the ground. **[1]**

This prevents any electric shock to the user. That is why Earthing of the electrical appliances is necessary. **[1]**

**Q. 6. Name two safety measures commonly used in electric circuits and appliances. [NCERT Q. 1, Page 238]**

**Ans.** Two safety measures are :

**(i)** Use of Earth wire and proper Earthing. **[1]**

**(ii)** Use of fuse (now-a-days fuse wire is replaced by MCB). **[1]**

**Q. 7. An electric oven of 2 kW power rating is operated in a domestic electric circuit (220 V) that has a current rating of 5 A. What result do you expect? Explain. [NCERT Q. 2, Page 238]**

**Ans.** Power rating of electric oven P = 2 kW = 2,000 W

Supply voltage V = 220 V

So, the current drawn by electric oven,

I = P/V = 2000 W/220 V = 9 A **[1]**

As the current rating of domestic electric circuit is only 5 A and the oven draws a current 9 A, which is more than the current rating, hence the circuit will be damaged due to overheating/overloading. **[1]**

**Q. 8. What precaution should be taken to avoid the overloading of domestic electric circuits?**
**[NCERT Q. 3, Page 238]**

**Ans.** The precautions that should be taken to avoid the overloading of domestic circuits are as follows :

**(i)** Too many appliances should not be connected to a single socket. **[½]**

**(ii)** Too many appliances should not be used at the same time. **[½]**

**(iii)** Faulty appliances should not be connected in the circuit. **[½]**

**(iv)** Fuse should be connected in the circuit. **[½]**

## Short Answer Type Questions

**(3 marks each)**

**A coil of insulated copper wire is connected toa 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?**
**[NCERT Ex. Q. 13, Page 241]**

**Ans.** A current induces in a solenoid if a bar magnet is moved relative to it. This is the principle of electro-magnetic induction.

**(i)** When a bar magnet is pushed into a coil of insulated copper wire, a current is induced momentarily in the coil. As a result, the needle of the galvanometer deflects momentarily in a particular direction. **[1]**

**(ii)** When the bar magnet is withdrawn from inside the coil of the insulated copper wire, a current is again induced momentarily in the coil in the opposite direction. As a result, the needle of the galvanometer deflects momentarily in the opposite direction. **[1]**

**(iii)** When a bar magnet is held stationary inside the coil, no current will be induced in the coil. Hence, galvanometer will show no deflection. **[1]**

**Q. 9. Two circular coils A and B are placed closed to each other. If the current in the coil A is changed, will some current be induced in the coil B? Give reason. [NCERT Ex. Q. 14, Page 241]**

**Ans.** Two circular coils A and B are placed closed to each other. When the current in the coil A is changed, the magnetic field associated with it will also change. **[1½]**
This change in magnetic field lines around coil B induces a current in it. That is called Electro-magnetic Induction. **[1½]**

**Q. 10. What is the difference between a direct current and an alternating current? How many times does AC used in India change direction in one second?**
**[NCERT Exemp. Q. 23, Page 100]**

**Ans.** The direction of current keeps on changing at frequent intervals in AC. But the direction of current always remains the same in DC. **[1½]**
In India, the AC changes direction 100 times per second. **[1½]**

**Q. 11. What is the role of fuse, used in series with any electrical appliance? Why should a fuse with defined rating not be replaced by one with a larger rating? [NCERT Exemp. Q. 24, Page 101]**

**Ans.** Fuse is used for protecting appliances due to short-circuiting or overloading. The fuse is rated for a certain maximum current and blows off when a current more than the rated value flows through it. **[1½]**
If a fuse is replaced by one with larger ratings, the appliances may get damaged while the protecting fuse does not burn off. This practice of using fuse of improper rating should always be avoided. **[1½]**

**Q. 12. When does an electric short circuit occur?**
**[NCERT Ex. Q. 17, Page 241]**

**Ans.** A common type of short circuit occurs when the positive and negative terminals of a battery are connected with a low-resistance conductor, like a wire. With a low resistance in the connection, a high current will flow, causing the delivery of a large amount of energy in a short period of time. **[1½]**
In simple terms, a short circuit gives electricity the path of least resistance between two conductive points. Less distance between the two points means less resistance, which means your short circuit will produce more heat and result in burns and fires. **[1½]**

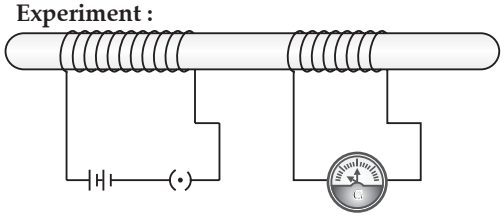
## Long Answer Type Questions

**(5 marks each)**

**Q. 1. Explain the phenomenon of electro-magnetic induction. Describe an experiment to show that a current is set up in a closed loop when an external magnetic field passing through the loop increases or decreases. [NCERT Exemp. Q. 30, Page 101]**

**Ans. Electro-magnetic induction :** This was first demonstrated by Michael Faraday in 1831. When a conductor and magnetic field are in motion relative to each other, electric current is induced in the conductor. This phenomenon is called electro-magnetic induction. **[1½]**

**Experiment :**



**[1½]**

**(i)** Take two coils with large number of turns. Let us assume that number of turns in one coil is 100 and in another coil it is 50.

**(ii)** Insert a cylinder of a non-conducting material through these coils.

**(iii)** Connect the coil with 50 turns to a galvanometer.

**(iv)** Connect the coil with 100 turns to a battery and plug key. **[1]**

**Observation :**

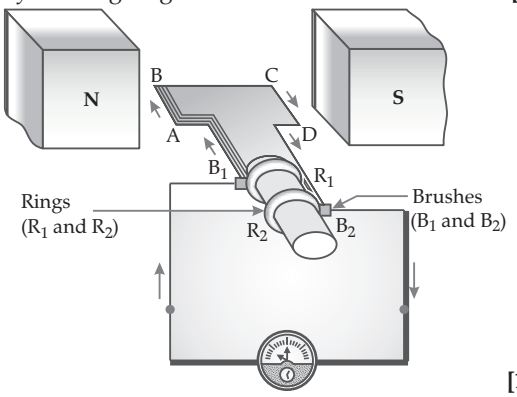
**(v)** When key is switched on, deflection is seen in galvanometer.

**(vi)** When key is switched off, deflection is seen in galvanometer; but in opposite direction.

**(vii)** This shows that whenever there is a change in strength of magnetic field, current is induced in the coil. **[1]**

**Q. 2. Explain the underlying principle and working of an electric generator by drawing a labelled diagram. What is the function of brushes?**
**[NCERT Ex. Q. 16, Page 241]**

**Ans. Principle :** An electric generator works on the principle of electro-magnetic induction phenomenon. According to it, whenever a coil is rotated between the poles of a magnet, an induced current is set up in the coil, whose direction is given by Fleming's right-hand rule. **[1]**




**[1]**

**Working :** When the axle attached to the two rings is rotated such that the arm AB moves up (and the arm CD moves down) in the magnetic field produced by the permanent magnet. The coil ABCD is rotated clockwise in the arrangement. By applying Fleming's right-hand rule, the induced currents are set up in these arms along the directions AB and CD. Thus, an induced current flows in the direction ABCD. If there are larger numbers of turns in the coil, the current generated in each turn adds up to give a large current through the coil. This means that the current in the external circuit flows from $B_2$ to $B_1$. After half a rotation, arm CD starts moving up and AB moving down. As a result, the directions of the induced currents in both the arms change, giving rise to the net induced current in the direction DCBA. The current in the external circuit now flows from $B_1$ to $B_2$. Thus, after every half rotation, the polarity of the current in the respective arms changes. Such a current, which changes direction after equal intervals of time, is called an alternating current (abbreviated as AC). This device is called an AC generator. **[2]**

**Function of brushes :** A brush is a device which conducts current between stationary wires and moving parts, most commonly in a rotating shaft. A carbon brush is a sliding contact used to transmit electrical current from a static to a rotating part in a motor or generator, and, as regards DC machines, ensuring a spark-free commutation. **[1]**

**Q. 3. Describe the working of an AC generator with the help of a labelled circuit diagram. What changes must be made in the arrangement to convert it to a DC generator? [NCERT Exemp. Q. 31, Page 101]**

**Ans. Construction :**

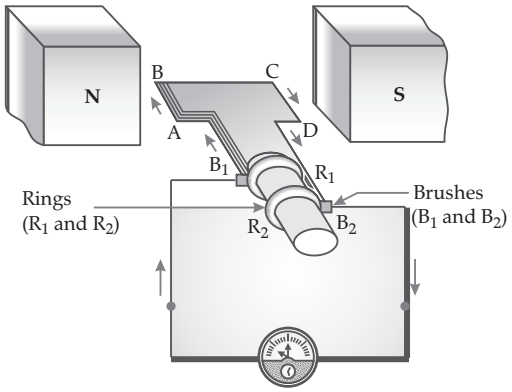
**(i)** ABCD is rectangular coil placed between the two poles of a permanent magnet.

**(ii)** Arms AB of coil are attached to a ring $R_1$ and arm CD is attached to the ring $R_2$.

**(iii)** $R_1$ and $R_2$ are insulated from inside and are attached to an axle.

**(iv)** A brush $B_1$ touches $R_1$ and another brush $B_2$ touches $R_2$.

**(v)** A galvanometer is connected to $B_1$ and $B_2$ to show the flow and direction of current in the circuit. **[1]**




**[1]**

**Working of AC Generator :**

**(i)** AC generator works in Fleming's Right Hand Rule.

**(ii)** When coil is rotated within the magnetic field, electric current is induced in it.

**(iii)** Let us assume that the coil is rotating clocking in this figure. This means, AB is moving up and CD is moving down.

**(iv)** When AB is moving up, current flows in it from A to B.

**(v)** When CD is moving down, current flows in it from C to D.

**(vi)** After half a turn; relative positions of AB and CD change. Now, CD is moving up hence current is moving from D to C. Similarly, AB is moving down hence current is moving from B to A.

**(vii)** So, after every half turn the direction of current changes in this generator. This means alternating current is being generated. **[2]**

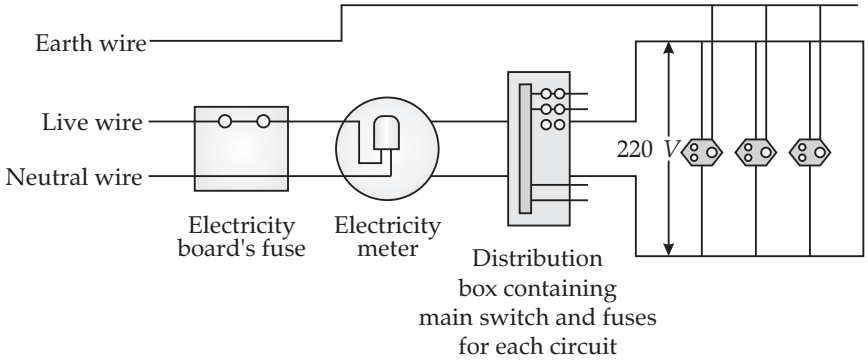
**Conversion of AC generator to DC generator :**

For this, a split ring commutator is used in place of two separate rings. A split ring commutator maintains the direction of current in one direction and it becomes a DC generator. **[1]**

**Q. 4. Draw an appropriate schematic diagram showing common domestic circuits and discuss the importance of fuse. Why is it that a burnt-out fuse should be replaced by another fuse of identical rating?**

**[NCERT Exemp. Q. 32, Page 101]**

**Ans.**




**[2½]**

**Important of fuse :**

**(i)** Fuse is an important safety device in household wiring and in electrical appliance.

**(ii)** Fuse prevents any damage to the circuit and appliance which may happen due to overload.

**(iii)** Fuse prevents accidental fire which may happen because of short circuit.

Fuse of a particular rating is used with a particular appliance. A fuse with lower rating would result in lot of inconveniences because of frequent need of changing the fuse. A fuse with higher rating would not serve the purpose because it will not melt even if the current exceeds the limit of the device. Hence, a burnt-out fuse should be replaced by another fuse of identical rating. **[2½]**

## Some Commonly Made Errors

- Students confuse to differentiate the AC and DC motors.
- Students confuse to determine the direction of electric current and Force exerted on the conductor.
- Students get confused with the term Fleming's left and right-hand rule.
- Generally, Students do not draw diagrams. Try to explain your answer by making suitable diagram.

### EXPERT ADVICE

- *Magnetism plays an important role in Electrical and Electronic Engineering because without it components such as relays, solenoids, inductors, chokes, coils, loudspeakers, motors, generators, transformers, and electricity meters, etc., would not work if magnetism did not exist. So, study all the concepts of electro-magnetism sharply.*
- *Try to understand the concept of Electro-magnetic induction.*
- *Use flowcharts to explain – Working of Electric generator and Electric motor.*
- *Draw suitable diagram to explain Fleming's rules of direction.*
- *Focus on important topic in electro-magnetism..*

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