

Class – 10 Science

Notes

Chapter-13 Magnetic Effects of Electric Current

Magnet: Magnetic field and magnetic field lines, Magnetic field due to a current carrying conductor, Right hand thumb rule, Magnetic field due to current through a circular loop. Magnetic field due to current in a solenoid. Magnet is an object that attracts objects made of iron, cobalt and nickel. Magnet comes to rest in North – South direction, when suspended freely.

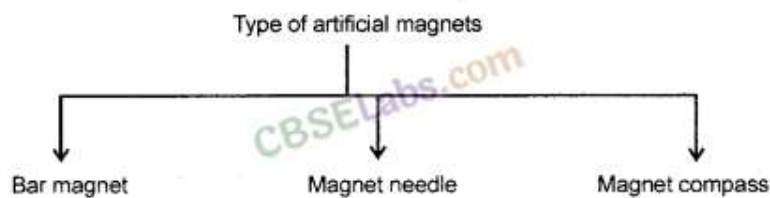
Use of Magnets: Magnets are used

- in refrigerators.
- in radio and stereo speakers.
- in audio and video cassette players.
- in children's toys and;
- on hard discs and floppies of computers.

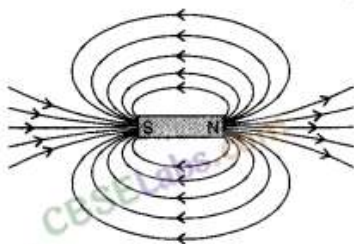
Properties of Magnet

- A free suspended magnet always points towards the north and south direction.
- The pole of a magnet which points toward north direction is called north pole or north-seeking.
- The pole of a magnet which points toward south direction is called south pole or south seeking.
- Like poles of magnets repel each other while unlike poles of magnets attract each other.

Magnetic field: The area around a magnet where a magnetic force is experienced is called the magnetic field. It is a quantity that has both direction and magnitude, (i.e., Vector quantity).



Magnetic field and field lines: The influence of force surrounding a magnet is called magnetic field. In the magnetic field, the force exerted by a magnet can be detected using a compass or any other magnet. The magnetic field is represented by magnetic field lines.



The imaginary lines of magnetic field around a magnet are called field line or field line of magnet. When iron filings are allowed to settle around a bar magnet, they get arranged in a pattern which mimicks the magnetic field lines. Field line of a magnet can also be detected using a compass. Magnetic field is a vector quantity, i.e. it has both direction and magnitude.

Direction of field line: Outside the magnet, the direction of magnetic field line is taken from North pole to South Pole. Inside the magnet, the direction of magnetic field line is taken from South pole to North pole.

Strength of magnetic field: The closeness of field lines shows the relative strength of magnetic field, i.e. closer lines show stronger magnetic field and vice – versa. Crowded field lines near the poles of magnet show more strength.

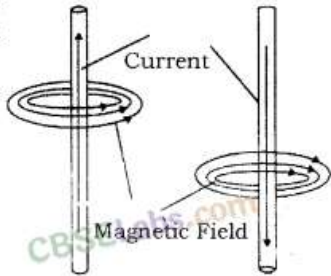
Properties of magnetic field lines

- (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 current a current carrying straight conductor

A current carrying straight conductor has magnetic field in the form of concentric circles, around it. Magnetic field of current carrying straight conductor can be shown by magnetic field lines.

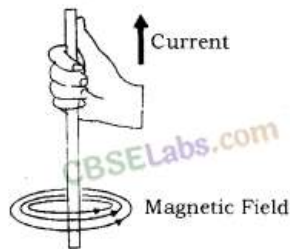
The direction of magnetic field through a current carrying conductor depends upon the direction of flow electric current.



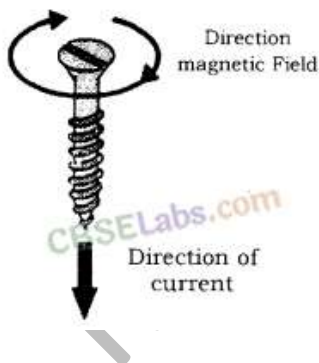
Let a current carrying conductor be suspended vertically and the electric current is flowing from south to north. In this case, the direction of magnetic field will be anticlockwise. If the current is flowing from north to south, the direction of magnetic field will be clockwise.

The direction of magnetic field, in relation to direction of electric current through a straight conductor can be depicted by using the Right Hand Thumb Rule. It is also known as Maxwell's Corkscrew Rule.

Right-Hand Thumb Rule: If a current carrying conductor is held by right hand, keeping the thumb straight and if the direction of electric current is in the direction of thumb, then the direction of wrapping of other fingers will show the direction of magnetic field.



Maxwell's Corkscrew rule: As per Maxwell's Corkscrew Rule, if the direction of forward movement of screw shows the direction of the current, then the direction of rotation of screw shows the direction of magnetic field.

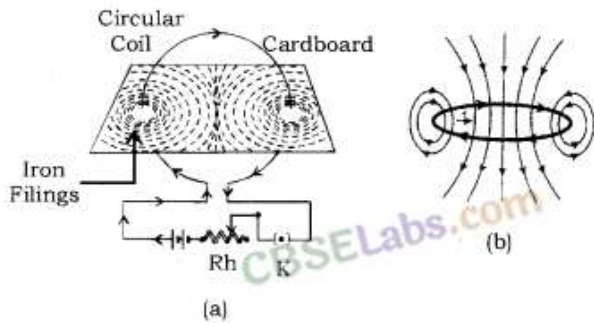


Properties of magnetic field

- The magnitude of magnetic field increases with increase in electric current and decreases with decrease in electric current.
- The magnitude of magnetic field produced by electric current decreases with increase in distance and vice – versa. The size of concentric circles of magnetic field lines increases with distance from the conductor, which shows that magnetic field decreases with distance.
- Magnetic field lines are always parallel to each other.
- No two field lines cross each other.

Magnetic field lines due to a current through a circular loop

In case of a circular current carrying conductor, the magnetic field is produced in the same manner as it is in case of a straight current carrying conductor.



In case of a circular current carrying conductor, the magnetic field lines would be in the form of iron concentric circles around every part of the coil's periphery of the conductor. Since, magnetic field lines tend to remain closer when near to the conductor, so the magnetic field would be stronger near the periphery of the loop. On the other hand, the magnetic field lines would be distant from each other when we move towards the centre of the current carrying loop. Finally, at the centre, the arcs of big circles would appear as a straight line.

The direction of the magnetic field can be identified using Right Hand Thumb's Rule. Let us assume that the current is moving in anti-clockwise direction in the loop. In that case, the magnetic field would be in clockwise direction, at the top of the loop. Moreover, it would be in an anti-clockwise direction at the bottom of the loop.

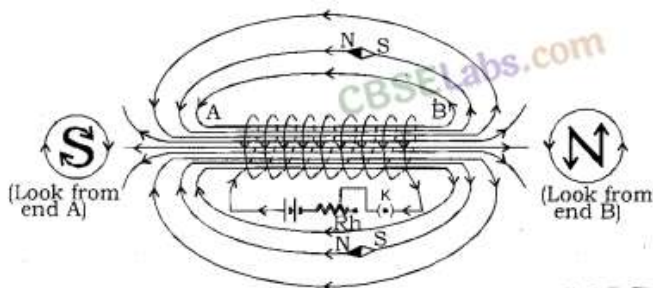
Clock Face Rule: A current carrying loop works like a disc magnet. The polarity of this magnet can be easily understood with the help of Clock Face Rule. If the current is flowing in anti-clockwise direction, then the face of the loop shows north pole. On the other hand, if the current is flowing in clockwise direction, then the face of the loop shows south pole.

Magnetic field and number of turns of coil: Magnitude of magnetic field gets summed up with increase in the number of turns of coil. If there are 'n' turns of coil, magnitude of magnetic field will be 'n' times of magnetic field in case of a single turn of coil.

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 field also increases.

Magnetic field due to a current in a Solenoid: Solenoid is the coil with many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. A current carrying solenoid produces similar pattern of magnetic field as a bar magnet. One end of solenoid behaves as the north pole and another end behaves as the south pole.



Magnetic field lines are parallel inside the solenoid, similar to a bar magnet, which shows that magnetic field is same at all points inside the solenoid.

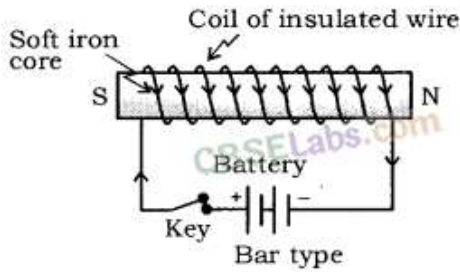
Magnetic field produced by a solenoid is similar to a bar magnet.

The strength of magnetic field is proportional to the number of turns and magnitude of current.

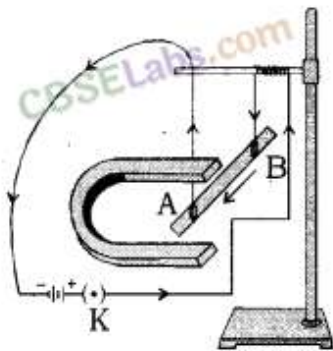
By producing a strong magnetic field inside the solenoid, magnetic materials can be magnetized. Magnet formed by producing magnetic field inside a solenoid is called electromagnet.

Electromagnet, Fleming's Left-Hand Rule, Electric motor, Electromagnetic induction, Fleming's right hand rule, Electric generator and domestic electric circuits.

Electromagnet: An electromagnet consists of a long coil of insulated copper wire wrapped on a soft iron. Magnet formed by producing magnetic field inside a solenoid is called electromagnet.



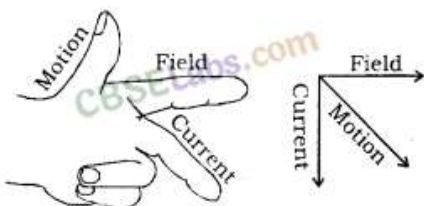
Force on a current carrying conductor in a magnetic field: A current carrying conductor exerts a force when a magnet is placed in its vicinity. Similarly, a magnet also exerts equal and opposite force on the current carrying conductor. This was suggested by Marie Ampere, a French Physicist and considered as founder of science of electromagnetism.



The direction of force over the conductor gets reversed with the change in direction of flow of electric current. It is observed that the magnitude of force is highest when the direction of current is at right angles to the magnetic field.

Fleming's Left-Hand Rule: If the direction of electric current is perpendicular to the magnetic field, the direction of force is also perpendicular to both of them. The Fleming's Left Hand Rule states that if the left hand is stretched in a way that the index finger, the middle finger and the thumb are in mutually perpendicular directions, then the index finger and middle finger of a stretched left hand show the direction of magnetic field and direction of electric current respectively and the thumb shows the direction of motion or force acting on the conductor. The directions of electric current, magnetic field and force are similar to three mutually perpendicular axes, i.e. x, y, and z-axes.

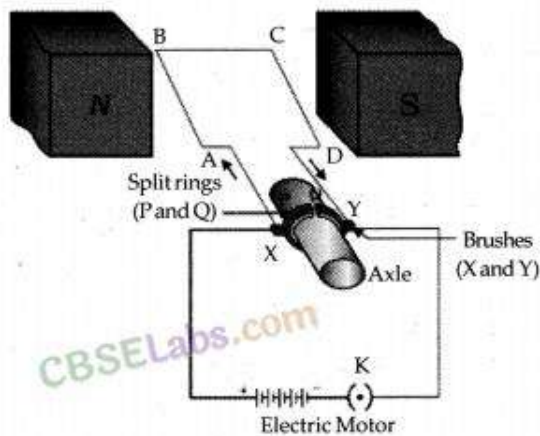
Many devices, such as electric motor, electric generator, loudspeaker, etc. work on Fleming's Left Hand Rule.



Electric motor: A device that converts electrical energy to mechanical energy. It is of two types: AC and DC 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.

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.



Construction: It consists of the following parts :

- Armature: It is a rectangular coil (ABCD) which is suspended between the two poles of a magnetic field. The electric supply to the coil is connected with a commutator.
- Commutator or Split – ring: Commutator is a device which reverses the direction of flow of electric current through a circuit. It is two halves of the same metallic ring.
- Magnet: Magnetic field is supplied by a permanent magnet NS.
- Sliding contacts or Brushes Q which are fixed.
- Battery: These are consists of few cells.

Working: When an electric current is supplied to the coil of the electric motor, it gets deflected because of magnetic field. As it reaches the halfway, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of the 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.

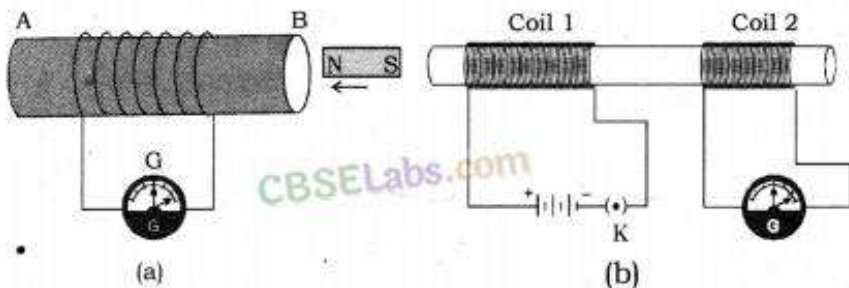
In commercial motor, electromagnet instead of permanent magnet and armature is used. Armature is a soft iron core with large number of conducting wire turns over it. Large number of turns of conducting wire enhances the magnetic field produced by armature.

Uses of motors :

- Used in electric fans.
- Used for pumping water.
- Used in various toys.

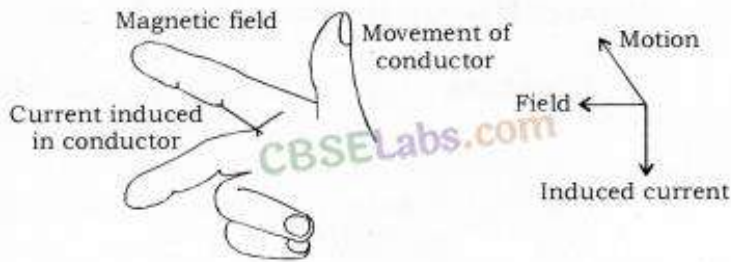
Electromagnetic Induction: Michael Faraday, an English Physicist is supposed to have studied the generation of electric current using a magnetic field and a conductor.

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



When a conductor is set to move inside a magnetic field or a magnetic field is set to be changing around a conductor, electric current is induced in the conductor. This is just opposite to the exertion of force by a current carrying conductor inside a magnetic field. In other words, when a conductor is brought in relative motion vis – a – vis a magnetic field, a potential difference is induced in it. This is known as electromagnetic induction.

Fleming's Right-Hand Rule: Electromagnetic induction can be explained with the help of Fleming's Right Hand Rule. If the right hand is structured in a way that the index (fore finger) finger, middle finger and thumb are in mutually perpendicular directions, then the thumb shows direction of induced current in the conductor, in conductor The directions of movement of conductor, magnetic field and induced current can be compared to three mutually perpendicular axes, i.e. x, y and z axes.

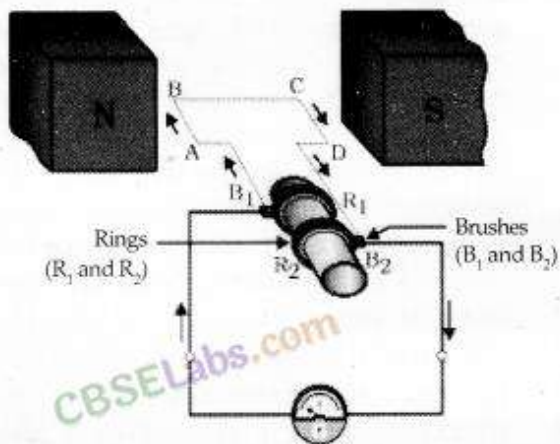


The mutually perpendicular directions also point to an important fact that when the magnetic field and movement of conductor are perpendicular, the magnitude of induced current would be maximum.

Electromagnetic induction is used in the conversion of kinetic energy into electrical energy.

Electric Generator: A device that converts mechanical energy into electrical energy is called an electric generator.

Electric generators are of two types: AC generator and a DC generator. Principle of electric generator: Electric motor works on the basis of electromagnetic induction.

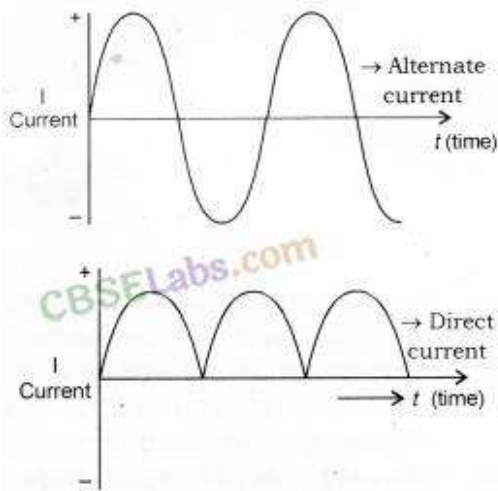


Construction and Working: The structure of an electric generator is similar to that of an electric motor. In case of an electric generator, a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in a way that it can move around an axle. When the armature moves within the magnetic field, an electric current is induced. 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. A.C. To convert an A.C generator into a D.C generator, a split ring commutator is used. This helps in producing direct current. Electrical generator is used to convert mechanical energy into electrical energy.

A.C and D.C Current

A.C – Alternate Current: Current in which direction is changed periodically is called Alternate Current. In India, most of the power stations generate alternate current. The direction of current changes after every $1/100$ second in India, i.e. the frequency of A.C in India is 50 Hz. A.C is transmitted upto a long distance without much loss of energy is advantage of A.C over D.C.



D.C – Direct Current: Current that flows in one direction only is called Direct current. Electrochemical cells produce direct current.
Advantages of A.C over D.C

- Cost of generation of A.C is much less than that of D.C.
- A.C can be easily converted to D.C.
- A.C can be controlled by the use of choke which involves less loss of power whereas, D.C can be controlled using resistances which involves high energy loss.
- AC can be transmitted over long distances without much loss of energy.
- AC machines are stout and durable and do not need much maintenance.

Disadvantages of AC

- AC cannot be used for the electrolysis process or showing electromagnetism as it reverses its polarity.
- AC is more dangerous than DC.

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

The 3 wires are as follows

- Live wire – (Red insulated, Positive)
- Neutral wire – (Black insulated, Negative)
- 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: Short-circuiting is caused by the touching of live wires and neutral wire and sudden a large current flows.

It happens due to

- damage of insulation in power lines.
- a fault in an electrical appliance.

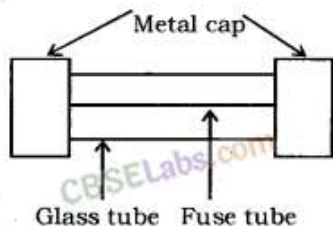
Overloading of an Electric Circuit: The overheating of electrical wire in any circuit due to the flow of a large current through it is called overloading of the electrical circuit.

A sudden large amount of current flows through the wire, which causes overheating of wire and may cause fire also.

Electric Fuse: It is a protective device used for protecting the circuit from short-circuiting and overloading. It is a piece of thin wire of material having a low melting point and high resistance.

- Fuse is always connected to live wire.

- Fuse is always connected in series to the electric circuit.
- Fuse is always connected to the beginning of an electric circuit.
- Fuse works on the heating effect.



Magnetic field: The area around a magnet in which other magnet feels force of attraction or repulsion is called Magnetic field.

Magnetic field lines: The closed curved imaginary lines in the magnetic field which indicate the direction of motion of north pole in the magnetic field if a magnet is free to do so.

Properties of magnetic field lines.

- Magnetic Field lines originate from the north pole of a magnet and end at its south pole.
- Magnetic Field lines are denser near the poles but rarer at other places.
- The Magnetic Field lines do not intersect one another.

Oersted's experiment: According to this experiment "A current carrying wire creates a magnetic field around it. The direction of magnetic field depends on the direction of current in conductor."

- Magnetic field pattern due to straight current carrying conductor are concentric circles whose center lie on the wire.
- The direction of magnetic field due to straight current carrying conductor can be determined by Right hand thumb rule.

Right hand thumb rule: According to this rule "if current carrying conductor is held in the right hand in such a way that thumb indicate the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor."

Magnetic field pattern due to current carrying loop: The Magnetic field lines are circular near the current-carrying loop. As we move away from the loop, field lines form bigger and bigger circles. At the center of the circular loop, the magnetic field lines are straight.

The solenoid is an insulated and tightly wound long circular wire having large number of turns whose radius is small in comparison to its length. Magnetic field produced by a solenoid is similar to the magnetic field produced by a bar magnet.

Current carrying solenoid is called an electromagnet.

Properties of magnetic lines of force or magnetic field lines.

- These lines originate from the north pole and end at the south pole.
- The magnetic field lines of a magnet form a continuous closed loop.
- Two magnetic lines of force do not intersect each other.
- The tangent at any point on the magnetic line gives the direction of the magnetic field at the point.

Fleming's left hand rule: According to this rule, "if the thumb, forefinger and middle finger of the left hand are stretched perpendicular to each other and if the fore-finger gives the direction of magnetic field, middle finger gives the direction of current, then the thumb will give the direction of motion or the force acting on the current-carrying conductor."

Principle of an electric motor: A motor works on the principle that when a rectangular coil is placed in a magnetic field and current passes through it, a force acts on the coil which rotates it continuously.

When the coil rotates, the shaft attached to it also rotates. In this way the electrical energy supplied to the motor is converted into the mechanical energy of rotation.

Principle of an electric generator: It is based on the principle of electromagnetic induction. It states that “an induced current is produced in a coil placed in a region where the magnetic field changes with time.” The direction of induced current is given by Fleming’s right-hand rule. An electric generator converts mechanical energy into electrical energy.

Electromagnetic induction: The phenomenon of setting up of an electric current or an induced e.m.f. by changing the magnetic lines of force by a moving conductor is called electromagnetic induction.

Maxwell’s right hand thumb rule: The direction of the current is given by Maxwell’s right-hand thumb rule, “If the current carrying conductor is gripped with the right hand in such a way that the thumb gives the direction of the current, then the direction of the fingers gives the direction of the magnetic field produced around the conductor.

Fleming’s left-hand rule: The direction of motion of a conductor in a magnetic field is given by Fleming’s left-hand rule. According to this rule, if the thumb, forefinger and middle finger of the left hand are stretched perpendicular to each other and if fore-finger gives the direction of the magnetic field and the middle finger gives the direction of current then, the thumb will give the direction of the motion of the conductor carrying the current.

Fleming’s right-hand rule: The direction of the induced current is given by Fleming’s right-hand rule. According to this rule if the thumb, forefinger and middle finger of the right hand are stretched perpendicular to each other and if the fore-finger gives the direction of the magnetic field and the thumb gives the direction of motion, then the middle finger will give the direction of the induced current in the conductor.

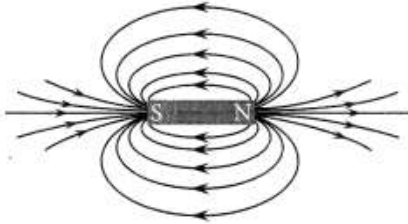
Important Questions of Magnetic Effects of Electric Current

Question 1. What is meant by magnetic field?

Answer: Magnetic field : It is defined as the space surrounding the magnet in which magnetic force can be experienced.

Question 2. Draw magnetic field lines around a bar magnet. Name the device which is used to draw magnetic field lines. (Board Term I, 2015)

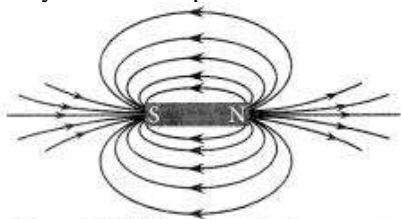
Answer:



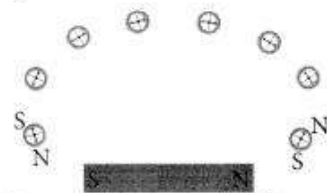
Compass needle is used to draw magnetic field lines.

Question 3. Design an activity to demonstrate that a bar magnet has a magnetic field around it. (Board Term I, 2017)

Answer: One can easily demonstrate the presence of field lines around a bar magnet using compass needles. Place the magnet on a white sheet and mark its boundaries on sheet. Place the compass near the north pole of magnet and mark the position of needle. Now move the compass such that its south pole occupies the position previously occupied by its north pole. Repeat this step several times and you will have pattern as shown in the figure.



Magnetic field lines around a bar magnet



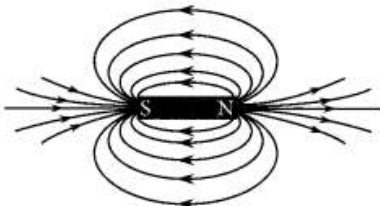
Drawing a magnetic field line with the help of a compass needle

Repeat the above procedure and draw as many lines as you can. These lines represent the magnetic field around the magnet. These are known as magnetic field lines.

Question 4. What are magnetic field lines? Justify the following statements:

- (a) Two magnetic field lines never intersect each other.
- (b) Magnetic field are closed curves. (Board Term I, 2016)

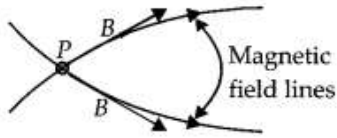
Answer: Imaginary continuous closed curves used to represent the magnetic field in a region is known as magnetic field lines. It is directed from north pole to south pole outside the magnet and south pole to north pole inside the magnet.



Magnetic field lines around a bar magnet

(a) The direction of magnetic field (B) at any point is obtained by drawing a tangent to the magnetic field line at that point. In case, two magnetic field lines intersect each other at the point P as shown in figure, magnetic field at P will have two directions, shown by

two arrows, one drawn to each magnetic field line at P, which is not possible.



(b) It is taken by convention that the field lines emerge from north pole and merge at the south pole. Inside the magnet, the direction of field lines is from its south pole to its north pole. Thus, the magnetic field lines are closed curves.

Question 5. (a) What is meant by a magnetic field? Mention two parameters that are necessary to describe it completely.

(b) If field lines of a magnetic field are crossed at a point, what does it indicate? (Board Term I, 2013)

Answer: (a) Refer to answer 1.

Necessary parameters are:

- Magnitude of magnetic field.
- Direction of field lines

(b) If field lines of a magnetic field are crossed at a point, it indicates that there are two directions of magnetic field at a point which is not possible.

Question 6. A compass needle is placed near a current carrying straight conductor. State your observation for the following cases and give reasons for the same in each case.

(a) Magnitude of electric current is increased.

(b) The compass needle is displaced away from the conductor. (AI 2019)

Answer: (a) As the amount of magnetic field strength is directly proportional to the amount of current, so the deflection of compass needle increases.

(b) Since magnetic field strength at a point is inversely proportional to the distance from the wire. Hence deflection of compass decreases when it is displaced away from the conductor.

Question 7. State how the magnetic field produced by a straight current carrying conductor at a point depends on

(a) current through the conductor

(b) distance of point from conductor. (Board Term I, 2014)

Answer: Strength of magnetic field produced by a straight current-carrying wire at a given point is

(a) directly proportional to the current passing through it.

(b) inversely proportional to the distance of that point from the wire.

$$\text{i.e., } B \propto \frac{I}{r} \left\{ \begin{array}{l} B \rightarrow \text{magnetic field} \\ I \rightarrow \text{current} \\ r \rightarrow \text{distance between wire and} \\ \quad \text{point of observation} \end{array} \right.$$

Question 8. Give reason for the following

(i) There is either a convergence or a divergence of magnetic field lines near the ends of a current carrying straight solenoid.

(ii) The current carrying solenoid when suspended freely rests along a particular direction. (2/3, 2020)

Answer: (i) There is either a convergence or a divergence of magnetic field lines near the ends of a current carrying straight solenoid because it behaves similar to that of a bar magnet and has a magnetic field line pattern similar to that of a bar magnet. Thus the ends of the straight solenoid behaves like poles of the magnet, where the converging end is the south pole and the diverging end is the north pole.

(ii) The current carrying solenoid behaves similar to that of a bar magnet and when freely suspended aligns itself in the north-south direction.

Question 9. Find the direction of magnetic field due to a current carrying circular coil held:

(i) vertically in North – South plane and an observer looking it from east sees the current to flow in anticlockwise direction,

(ii) vertically in East – West plane and an observer looking it from south sees the current to flow in anticlockwise direction,

(iii) horizontally and an observer looking at it from below sees current to flow in clockwise direction. (Board Term I, 2017)

Answer: According to right hand rule, the direction of magnetic field is

(i) west to east

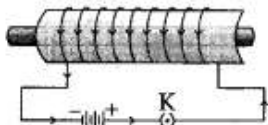
- (ii) north to south
- (iii) into the paper.

Question 10. (a) State three factors on which the strength of magnetic field produced by a current carrying solenoid depends.
 (b) Draw circuit diagram of a solenoid to prepare an electromagnet. (Board Term I, 2016)

Answer: (a) Strength of magnetic field produced by a current carrying solenoid depends upon the following factors:

- number of turns in the coil
- amount of current flowing through it
- radius of coil
- Material of core of the solenoid.

(b) A strong magnetic field produced inside a solenoid can be used to magnetise a piece of magnetic material, like soft iron, when placed inside the coil. The magnet so formed is called an electromagnet.



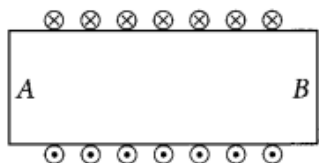
An electromagnet-A current-carrying solenoid coil which is used to magnetise steel rod inside it.

Question 11. (a) State Right Hand Thumb rule to find the direction of the magnetic field around a current carrying straight conductor.
 (b) How will the magnetic field be affected on:
 (i) increasing the current through the conductor
 (ii) reversing the direction of flow of current in the conductor? (Board Term I, 2015)

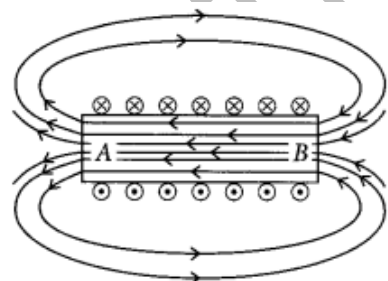
Answer: (a) It states that you are holding a current carrying straight conductor in your right hand such that the thumb points towards the direction of current. Then your finger will wrap around the conductor in the direction of the field lines of the magnetic field.

- (b) (i) If the current is increased, the magnetic field strength also increases.
- (ii) If the direction of current is reversed, the direction of magnetic field also get reversed.

Question 12. Diagram shows the lengthwise section of a current carrying solenoid. \otimes indicates current entering into the page, \odot indicates current emerging out of the page. Decide which end of the solenoid A or B, will behave as north pole. Give reason for your answer. Also draw field lines inside the solenoid.



Answer:



Using right hand thumb rule we can draw the magnetic field lines around the conductor as shown. From figure, end A of solenoid act as north pole and end B will act as south pole. Inside the solenoid field lines are in the form of parallel straight lines.

Question 13. Write one application of right hand thumb rule. (1/3, Board Term I, 2013)

Answer: It is used to find the direction of magnetic field around a current carrying conductor.

- Question 14. (a) What is an electromagnet? List any two uses.
 (b) Draw a labelled diagram to show how an electromagnet is made.
 (c) State the purpose of soft iron core used in making an electromagnet.
 (d) List two ways of increasing the strength of an electromagnet if the material of the electromagnet is fixed. (2020)

Answer: (a, b) Refer to answer 10(b).

Electromagnets are used in electric motors and generators, electric bells and buzzers, loudspeakers and headphones etc.

(c) The soft iron core placed in an electromagnet increases the strength of the magnetic field produced. Thus increasing the strength of electromagnet.

(d) The strength of electromagnet can be increased by

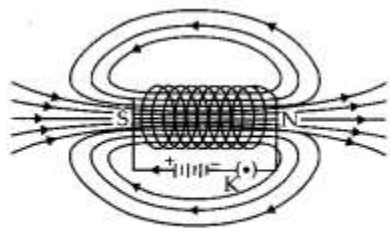
- (i) Increasing the current passing through the coil.
- (ii) Increasing the number of turns in the coil.

Question 15. What is solenoid? Draw the pattern of magnetic field lines of

- (i) a current carrying solenoid and
- (ii) a bar magnet.

List two distinguishing features between the two fields. (Delhi 2019)

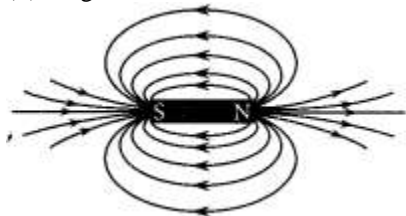
Answer: (i) Solenoid : A coil of many circular turns of insulated copper wire wrapped in the shape of cylinder is called solenoid.



Field lines of the magnetic field through and around a current-carrying solenoid

The pattern of magnetic field lines inside the solenoid indicates that the magnetic field is the same at all points inside the solenoid. That is, the field is uniform inside the solenoid.

(ii) Magnetic field lines around a bar magnet.



Following are the distinguishing features between the two fields.

- (a) A bar magnet is a permanent magnet whereas solenoid is an electromagnet, therefore field produced by solenoid is temporary and stay till current flows through it.
- (b) Magnetic field produced by solenoid is more stronger than magnetic field of a bar magnet.

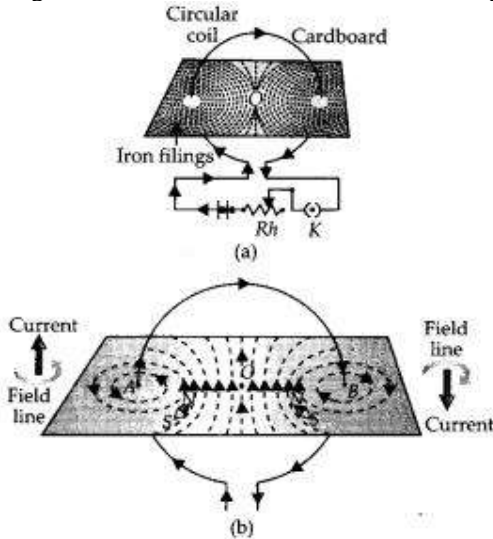
Question 16. What are magnetic field lines? List three characteristics of these lines. Describe in brief an activity to study the magnetic field lines due to a current carrying circular coil. (Board Term I, 2017, 2016)

Answer: Magnetic field lines : These are the imaginary close curves which are used to represent the magnetic field around the magnet. The properties of the magnetic field lines are listed below:

- Magnetic field lines start at the north pole and end at the south pole.
- Magnetic field lines do not intersect each other, because there cant be two directions of the magnetic field at any one point.
- The degree of closeness of the field lines depends upon the strength of the magnetic field. Stronger the field, closer are the field lines.

In order to find the magnetic field due to a coil, it is held in a vertical plane and is made to pass through a smooth cardboard in such a way that the centre (O) of the coil lies at the cardboard. A current is passed through the coil and iron filings are sprinkled on the cardboard. These iron filings arrange themselves in a pattern similar to one shown in the figure. This pattern represents the magnetic field lines due to the coil.

In order to find the direction of magnetic field lines, we plot the magnetic field with the help of a compass needle. The pattern of magnetic field lines so obtained is shown in figure (b). From this pattern, the following important conclusion have been drawn.

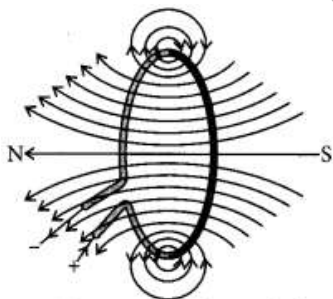


- The magnetic field lines near the coil are nearly circular and concentric. This is due to the reason that the segments of the coil in contact with the board at the points A and B are almost like straight conductors. The direction of the field lines can also be found by applying right-hand thumb rule.
- The field lines are in the same direction in the space enclosed by the coil.
- Near the centre of the coil, the field lines are nearly straight and parallel. As such the magnetic field at the centre of the coil can be taken to be uniform.
- The direction of the magnetic field at the centre is perpendicular to the plane of the coil.
- As we move towards the centre of the coil, the strength of magnetic field increases. Magnetic field is maximum at its centre. This is due to the reason that the two magnetic field (one due to the semicircular segment of the coil through A and the other due to the semicircular segment through B) assist each other.

The magnitude of the magnetic field at the centre of the coil is directly proportional to the current flowing through it and total number of turns and inversely proportional to the radius of the coil. This is due to the reason that the current in all the circular turns of the coil is in the same direction. As such, the resultant magnetic field due to the coil is equal to the sum of the field due to all these turns.

Question 17. Draw the magnetic field lines through and around a single loop of wire carrying electric current. (2/5, Board Term I, 2016)

Answer:



Magnetic field lines of the field produced by a current-carrying circular loop.

Question 18. What is a solenoid? Draw a diagram to show field lines of the magnetic field through and around a current carrying solenoid. State the use of magnetic field produced inside a solenoid. List two properties of magnetic lines of force. (Board Term I, 2015)

Answer: Refer to answer 15(i).

Solenoid is used to form strong but temporary magnet called electromagnets. These electromagnets are used in wide variety of instruments and used to lift heavy iron, objects.

Properties of magnetic field lines :

Refer to answer 16.

Question 19. State the effect of a magnetic field on the path of a moving charged particle. (Board Term I, 2014)

Answer: A charged particle moving in a magnetic field may experience a force in the direction perpendicular to direction of magnetic field and direction of motion of particle. This force deflects the charged particle from its path.

Question 20. State the direction of magnetic field in the following case.



Answer: Using Fleming's left hand rule, the direction of magnetic field is out of the plane of paper.

Question 21. Write one application of Fleming's left hand rule. (1/3, Board Term I, 2013)

Answer: Fleming's left hand rule is used to find the direction of force on a current carrying conductor placed in a magnetic field acting perpendicular to the direction of current.

Question 22. A current carrying conductor is placed in a magnetic field. Now answer the following.

- List the factors on which the magnitude of force experienced by conductor depends.
- When is the magnitude of this force maximum?
- State the rule which helps, in finding the direction of motion of conductor.
- If initially this force was acting from right to left, how will the direction of force change if:
 - direction of magnetic field is reversed?
 - direction of current is reversed? (Board Term I, 2017)

Answer:

(i) When a current carrying wire is placed in a magnetic field, it experiences a magnetic force that depends on

- current flowing in the conductor
- strength of magnetic field
- length of the conductor
- angle between the element of length and the magnetic field.

(ii) Force experienced by a current carrying conductor placed in a magnetic field is largest when the direction of current is perpendicular to the direction of magnetic field.

(iii) The rule used in finding the direction of motion of the conductor placed in a magnetic field is Fleming's left hand rule.

Fleming's left hand rule is as follows:

Stretch out the thumb, the forefinger, and the second (middle) finger of the left hand so that these are at right angles to each other. If the forefinger gives the direction of the magnetic field (N to S), the second (middle) finger the direction of current then the thumb gives the direction of the force acting on the conductor.

(iv) (a) Direction of force will be reversed when direction of magnetic field is reversed, i.e., now force on conductor will act from left to right.

(b) Direction of force will be reversed, if the direction of current is reversed, i.e., the force on the conductor will act from left to right.

Question 23. State whether an alpha particle will experience any force in a magnetic field if (alpha particles are positively charged particles)

- it is placed in the field at rest.
- it moves in the magnetic field parallel to field lines.
- it moves in the magnetic field perpendicular to field lines.

Justify your answer in each case. (Board Term I, 2016)

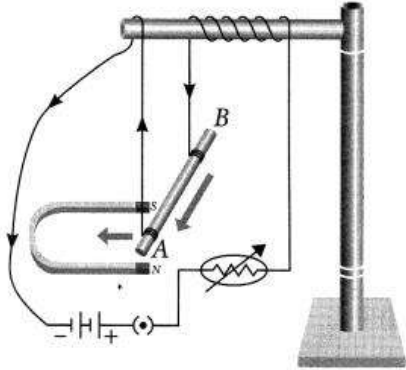
Answer:

(i) No, alpha particle will not experience any force if it is at rest, because only moving charge particle can experience force when placed in a magnetic field.

(ii) No, alpha particle will not experience any force if it moves in the magnetic field parallel to field lines because charge particle experiences force only when it moves at an angle other than 0° with magnetic field.

(iii) Alpha particle will experience a force in the direction perpendicular to the direction of magnetic field and direction of motion of alpha particle.

Question 24. Describe an activity with labelled diagram to show that a force acts on current carrying conductor placed in a magnetic field and its direction of current through conductor. Name the rule which determines the direction of this force. (Board Term I, 2016)
Answer: A small aluminium rod suspended horizontally from a stand using two connecting wires. Place a strong horseshoe magnet in such a way that the rod lies between the two poles with the magnetic field directed upwards. For this, put the north pole of the magnet vertically below and south pole vertically above the aluminium rod.



Connect the aluminium rod in series with a battery, a key and a rheostat. Pass a current through the aluminium rod from one end to other (B to A). The rod is displaced towards left. When the direction of current flowing through the rod is reversed, the displacement of rod will be towards right. Direction of force on a current carrying conductor is determined by Fleming's left hand rule.

Question 25. (a) State Fleming's left hand rule.
(b) Write the principle of working of an electric motor.
(c) Explain the function of the following parts of an electric motor.
(i) Armature (ii) Brushes (iii) Split ring (2018)

Answer: (a) Refer to answer 22 (iii).

(b) Principle : Current carrying conductor when placed at right angle to a magnetic field, experiences a force due to which we get motion. The direction of the force is given by Fleming's left hand rule.

(c) (i) Armature is a conductive part of motor which generates torque in the motor.
(ii) The two stationary brushes in a simple electric motor draw current from the battery and supply it to the armature of motor.
(iii) The role of split ring is to change the direction of current flowing through the coil after each half-rotation of coil.

Question 26. The change in magnetic field lines in a coil is the cause of induced electric current in it. Name the underlying phenomenon. (2020)

Answer: The phenomenon in which electric current is generated by varying magnetic fields around a coil is called electromagnetic induction.

Question 27. Define the term induced electric current. (2020)

Answer: The current induced in a conductor when the magnetic field around it changes is known as induced electric current.

Question 28. Fleming's Right-hand rule gives

- (a) magnitude of the induced current.
- (b) magnitude of the magnetic field.
- (c) direction of the induced current.
- (d) both, direction and magnitude of the induced current. (2020)

Answer: (c) Fleming's Right-hand rule gives the direction of induced current.

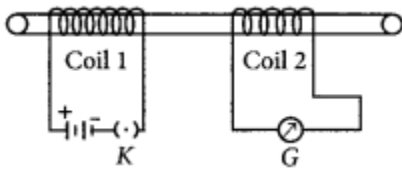
Question 29. What is the function of a galvanometer in a circuit? (Delhi 2019)

Answer: Galvanometer is an instrument that can detect the presence of electric current in a circuit.

Question 30. Write any one method to induce current in a coil. (Board Term I, 2016)

Answer: By keeping the magnet in a fixed position and moving the coil towards and away from the magnet, we can induce current in the coil.

Question 31. Two coils of insulated copper wire are wound over a non-conducting cylinder as shown. Coil 1 has comparatively large number of turns. State your observations, when



- (i) Key K is closed
- (ii) Key K is opened

Give reason for each of your observations. (2020)

Answer:

(i) When key is closed, after setting up the circuit as shown, one can observe a deflection on the galvanometer connected to the second coil. This is because, a potential difference and thus a current is induced in coil 2 as there is change in the current and the magnetic field associated with it in coil 1. When the magnetic field changes in coil 1, the magnetic field lines around coil 2 also changes. This induces a current in coil 2.

(ii) When key K is opened, after closing it for sometime it can be observed that the galvanometer show a deflection, but this time in the opposite direction. This is because, when the current stops flowing in coil 1, the magnetic field associated with it changes in the opposite direction as in the first case, thus inducing a current in the opposite direction.

Question 32. Two circular coils P and Q are kept close to each other, of which coil P carries a current. What will you observe in the galvanometer connected across the coil Q

- (a) if current in the coil P is changed?
- (b) if both the coils are moved in the same direction with the same speed?

Give reason to justify your answer in each

Answer:

(a) When the amount of current in the coil P is changed, an induced current will induce in the coil Q due to change in magnetic field lines i.e., magnetic flux.

(b) If both the coils are moved in the same direction with the same speed, then there is no net change in magnetic flux. Hence there will be no deflection in the galvanometer.

Question 33. In Faradays experiment if instead of moving the magnet towards the coil we move the coil towards the magnet. Will there be any induced current? Justify your answer. Compare the two cases. (Board Term I, 2017)

Answer: Yes, these will be an induced current in both the cases as there is a change in the number of magnetic field line associated with the coil or we can say that there is a motion of a magnet with respect to the coil.

Same of current will be induced and the direction of flow of current will also be the same in the two cases.

Question 34. Write one application of Fleming's right hand rule. (1/3, Board Term I, 2013)

Answer: Flemings right hand rule is used to find the direction of induced current.

Question 35.

(a) A coil of insulated copper wire is connected to a galvanometer. With the help of a labelled diagram state what would be seen if a bar magnet with its south pole towards one face of this coil is

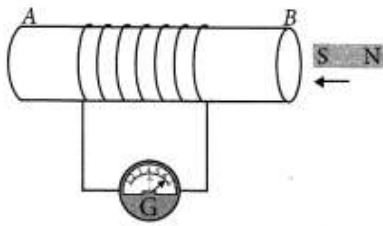
- (i) moved quickly towards it,
- (ii) moved quickly away from it,
- (iii) placed near its one face?

(b) Name the phenomena involved in the above cases.

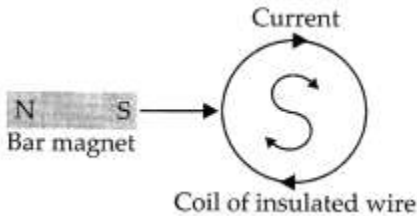
(c) State Fleming's right hand rule. (Board Term I, 2017)

Answer:

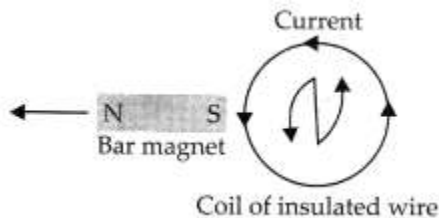
(a) If a coil of insulated wire is connected to a galvanometer and a bar magnet with south pole is moved towards one face of the coil then, given situation is shown in the figure.



(i) Moved quickly towards the coil : A current is induced in clockwise direction in the coil with respect to the side facing the north pole of the magnet and needle of galvanometer will deflect in one direction from zero position.



(ii) Moved quickly away from coil : A current is induced in anti-clockwise direction in the coil with respect to the side facing the north pole of the magnet and the needle of the galvanometer will deflect in opposite direction from (i).



(iii) Placed near its one face : No deflection of the needle of galvanometer is observed.

(b) The phenomena involved is called electromagnetic induction.

(c) Fleming's right hand rule: Stretch the right hand such that the first finger, the central finger and the thumb are mutually perpendicular to each other.

If the first finger points along the direction of the field (magnetic field) and the thumb points along the direction of motion of the conductor, then the direction of induced current is given by the direction of the central finger.

Question 36. Write the frequency of alternating current (AC) in India. How many times per second it changes its direction? (Board Term I, 2015)

Answer: The frequency of A.C. in India is 50 Hz and it changes direction twice in each cycle. Therefore, it changes direction $2 \times 50 = 100$ times in one second.

Question 37. How is the type of current that we receive in domestic circuit different from the one that runs a clock? (Board Term I, 2014)

Answer: The current that we receive from domestic circuit is alternating current (A.C.) and the current that issue to run clock is direct current (D.C.). Direct current always flow in one direction whereas the alternating current reverses its direction periodically.

Question 38. Define alternating current and direct current.

Explain why alternating current is preferred over direct current for transmission over long distances. (Board Term I, 2014)

Answer: Alternating current (A.C.) : An electric current whose magnitude changes with time and direction reverses periodically is called alternating current.

Direct current (D.C.) : An electric current whose magnitude is either constant or variable but the direction of flow in a conductor remains the same is called direct current.

A.C. can be transmitted to distant places without much loss of electric power than D.C. That is why A.C. is preferred over D.C. for transmission of current over a long distances.

Question 39.

(i) Alternating current has a frequency of 50 Hz. What is meant by this statement? How many times does it change its direction in one second? Give reason for your answer.

(ii) Mention the frequency of D.C that is given by a cell. (Board Term I, 2013)

Answer:

- (i) The frequency of household supply of A.C. in India is 50 Hz. This means, A.C. completes 50 cycles in one second. Thus, A.C. changes direction $2 \times 50 = 100$ times in one second.
- (ii) Frequency of D.C. is zero as its direction does not change with time.

Question 40. At the time of short circuit, the electric current in the circuit.

- (a) vary continuously
- (b) does not change
- (c) reduces substantially
- (d) increases heavily. (2020)

Answer: (d) At the time of short circuit, the live and neutral wire come in direct contact, thus increasing the current in the circuit abruptly.

Question 41. Mention and explain the function of an earth wire. Why it is necessary to earth metallic appliances? (Board Term I, 2013)

Answer: Many electric appliances of daily use like electric press, heater, toaster, refrigerator, table fan etc. have a metallic body. If the insulation of any of these appliances melts and makes contact with the metallic casing, the person touching it is likely to receive a severe electric shock. This is due to the reason that the metallic casing will be at the same potential as the applied one. Obviously, the electric current will flow through the body of the person who touches the appliance. To avoid such serious accidents, the metal casing of the electric appliance is earthed. Since the earth does not offer any resistance, the current flows to the earth through the earth wire instead of flowing through the body of the person.

Question 42. Give reason for the following :

The burnt out fuse should be replaced by another fuse of identical rating. (1/3, 2020)

Answer: A burnt out fuse should be replaced with identical rating because it helps in protecting the circuit from overloading and short circuiting. If a fuse of higher rating is used then it may not melt and cut off the supply during overloading. Similarly a fuse of lower rating may melt frequently even for a normal flow of current. This results in decreasing the efficiency of the circuit.

Question 43. Give reasons for the following:

- (a) It is dangerous to touch the live wire of the main supply rather than neutral wire.
- (b) In household circuit, parallel combination of resistances is used.
- (c) Using fuse in a household electric circuit is important. (Board Term I, 2017)

Answer:

- (a) Live wire is at 220V and neutral wire is at zero volt since the electric current flows from higher potential to lower potential, we can get an electric shock by touching live wire but that is not the case with neutral wire.
- (b) In parallel combination, each resistor gets same potential from the source. We can use separate on/off switches with each appliance. Also in case if any one resistor fails then the circuit will not break. So, it is safe and convenient to connect household circuit in parallel combination of resistors
- (c) Fuse is an important safety device. It is used in series with any electrical appliance and protects it from short-circuiting and overloading.

Question 44.

(a) Fuse acts like a watchman in an electric circuit. Justify this statement.

(b) Mention the usual current rating of the fuse wire in the line to (i) lights and fans (ii) appliance of 2 kW or more power. (Board Term I, 2014)

Answer:

(a) When an unduly high electric current flows through the circuit, the fuse wire melts due to joule heating effect and breaks the circuit. Hence, it keeps an eye on the amount of current flowing and also stops the current if exceeds the maximum value. So, fuse acts like a watchman in an electric circuit.

(b) (i) A fuse of rating 5A is usually used for lights and fans.

(ii) A fuse of rating 15 A is usually used for appliance of 2 kW or more power.

Question 45.

- (a) State Fleming's Left-hand rule.
- (b) List three characteristic features of the electric current used in our homes.
- (c) What is a fuse? Why is it called a safety device?
- (d) Why is it necessary to earth metallic electric appliances? (2020)

Answer:

(a) Refer to answer 22(iii).

(b) (i) The electric current which we receive in our homes are alternating current with a frequency of 50 Hz.

(ii) There are mainly two wires used in the power supply provided to us. The one usually with a red insulation is called the live wire (or positive wire) and the one with black insulation is called the neutral wire (or negative wire). The potential difference between these wires is 220 V.

(iii) Often, there are two separate circuits used in our homes, one of 15 A current rating for appliances with higher power rating and the other circuit of 5 A rating for appliances such as fans, bulbs, etc.

(c) A fuse is safety device use to limit the current in an electric circuit.

Refer to answer 44(a).

(d) Refer to answer 41.

Question 46.

(a) Name two safety measures commonly used in an electric circuit and appliances.

(b) What precaution should be taken to avoid the overloading of domestic electric circuits? (Board Term I, 2017)

Answer:

(a) Fuse and the connection of earthing wire are the two safety measure commonly used in electric circuit and appliances.

(b) Provide fuses/MCBs of proper rating.

Question 47.

(a) Draw a schematic diagram of a common domestic circuit showing provision of

(i) Earth wire, (ii) Main fuse

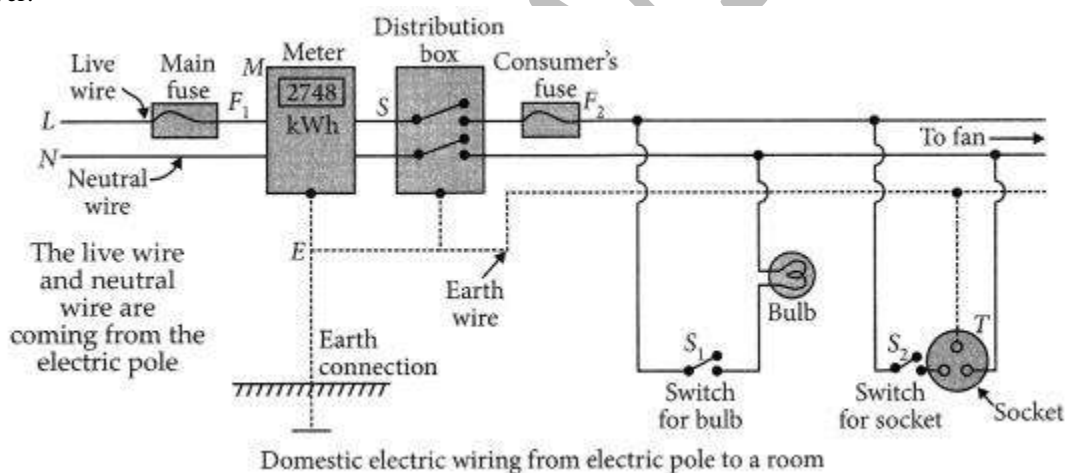
(iii) Electricity meter and

(iv) Distribution box.

(b) Distinguish between short circuiting and overloading. (Board Term I, 2015)

Answer:

(a)



(b) Overloading : The condition in which a high current flows through the circuit and at the same time too many appliances are switched on then the total current drawn through the circuit may exceed its rated value.

Short circuiting: The condition when the live wire comes in direct contact with the neutral wire, due to which a high current flows in the circuit.