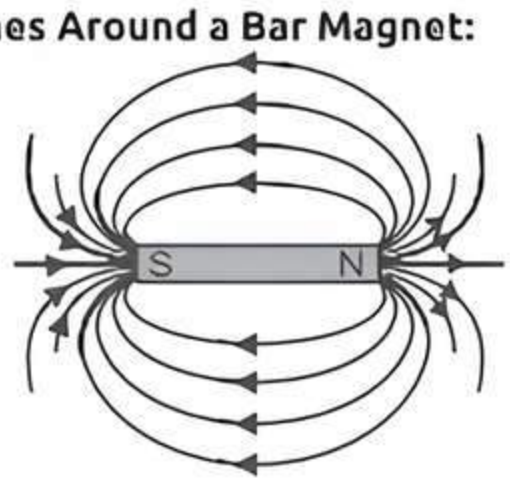
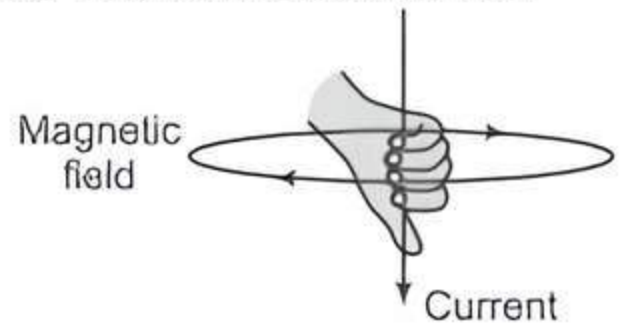
12 Magnetic Effects of Electric Current

Fastrack Revision

- **Magnet:** It is an object that attracts iron, cobalt and nickel particles. When it is suspended freely, it comes to rest in North-South direction.
- **Magnetic Field:** The space around a magnet in which the force of attraction or repulsion can be detected is called a magnetic field. It is a vector quantity. The SI unit of magnetic field is **tesla**.
- **Magnetic Field Lines:** These are curved paths along which the iron filings arrange themselves near a bar magnet due to the force acting on them in the magnetic field. They are also called magnetic field lines. These lines always emerge from N-pole of a magnet and merge at the S-pole of the magnet. Field lines never intersect each other.
- **Magnetic Lines Around a Bar Magnet:**

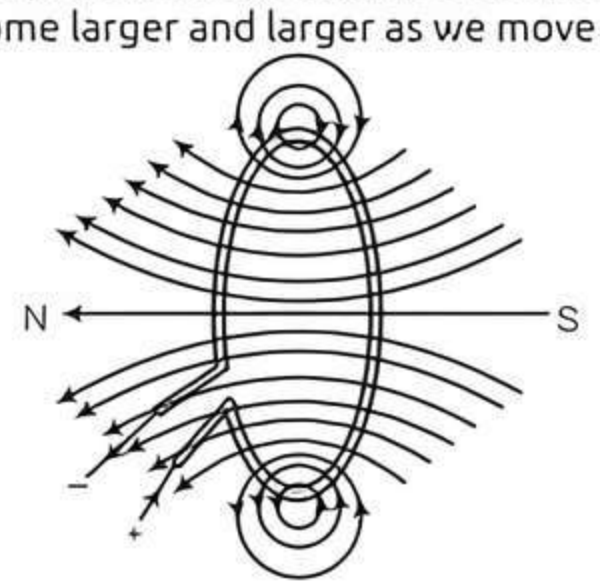


- **Right-Hand Thumb Rule:** This rule states that if a current carrying conductor is held in the right hand in such a way that thumb indicates the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor. It is also called Maxwell's right-hand thumb rule or Maxwell's corkscrew rule.

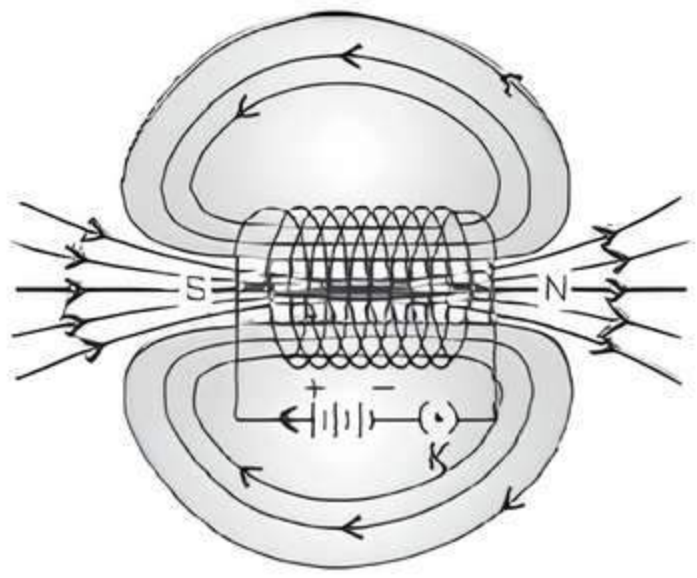


Magnetic field produced by a current carrying straight wire depends inversely on the distance from it and directly on the current passing through it.

- **Magnetic Field Produced by a Current Carrying Circular Loop:** It is represented by concentric circles at every point which become larger and larger as we move away.



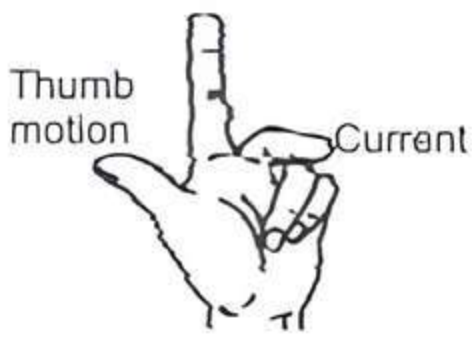
- **Solenoid:** It is a coil of many turns of insulated copper wire wrapped in the shape of a cylinder. The strength of magnetic field is proportional to the number of turns, magnitude of current and the nature of 'core material'.
- **Magnetic Field Lines through and Around a Current Carrying Solenoid**



- **Electromagnet:** An electromagnet refers to a magnetised solenoid which works on the principle of magnetic effect of current. The magnetic effect continues till the current flows through the solenoid. An electromagnet consists of a long insulated copper wire wound around a soft iron core. The electromagnets are used in electric motors, electric bells, loudspeakers, etc. Giant electromagnets are also used in cranes and lifts.
- **Force on a Current Carrying Conductor in Magnetic Field:** When a current carrying conductor is placed in a magnetic field, it experiences a magnetic force that depends on current flowing in the conductor, magnetic field, length of the conductor and direction of current and the direction of magnetic field.

  Force experienced by the conductor is maximum when the direction of current is at right angles to the direction of the magnetic field.
- **Fleming's Left-Hand Rule:** It is used to find out the direction of motion of a current carrying conductor when placed in a magnetic field. This rule is stated as, 'Stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular to each other.

Field



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

MNEMONICS

Concept: *Fleming's Left-Hand Rule*

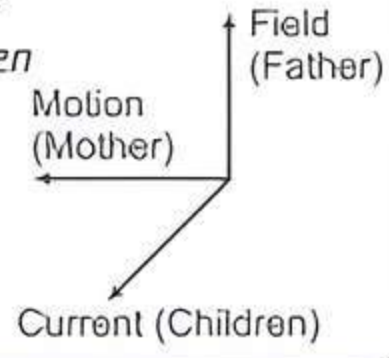
Mnemonics: ***F****ather,* ***M****other,* ***C****hildren*

Interpretation:

F – Field

M – Motion

C – Current



- **Direct Current (DC):** A current that always flows in the same direction through an electrical device is called a direct current.
- **Alternating Current (AC):** An electric current that reverses its direction periodically is called an alternating current. The frequency of AC in the Indian power supply is 50 HZ.

  Advantage of AC over DC: AC can be transmitted over long distances without much loss of energy.
- **Domestic Electric Circuits**
  (i) The electricity supplied to our houses by the electricity board is Alternating Current (AC) at 220 V and 500 Hz frequency. Each home is fitted with two different supplies, *viz.*, 5 A and 15 A. The 5 A supply (called domestic light) is used for bulbs, fans, TVs, etc., and the 15 A supply (called domestic power) is used for heaters, coolers, air conditioners, geysers, etc.
  (ii) We connect all the domestic electrical circuits in parallel because:
    (a) When two or more appliances are used at the same time, each appliance will be able to draw current as per the requirement.
    (b) When distribution circuits are in parallel, then each circuit operates separately. So, if one of the distribution circuits gets overloaded, only the fuse in that circuit will be blown off.
  (iii) Most of the electrical appliances are connected to the source of electricity by a three-core flexible cable containing live, neutral and earth.
- **Overloading:** The overheating of electrical wiring in any circuit, due to the flow of large current through it, is called overloading of the electrical circuit.
- **Electric Fuse:** A fuse is a piece of thin wire made up of a material having a low melting point and high resistance. Fuse wire is made from an alloy of lead and tin. Fuse is always connected in the live wire and in series with electrical circuit, to protect it from overloading or short-circuiting.
- **Earthing of Electrical Appliances:** Connecting the metallic body of an electrical appliance to a metal plate deep in the earth by the earth wire is called the **earthing of an electrical appliance**. Earth wire is used for safety measure to ensure that any leakage of current in a metallic body does not give any serious shock to a user.

Practice Exercise

Multiple Choice Questions

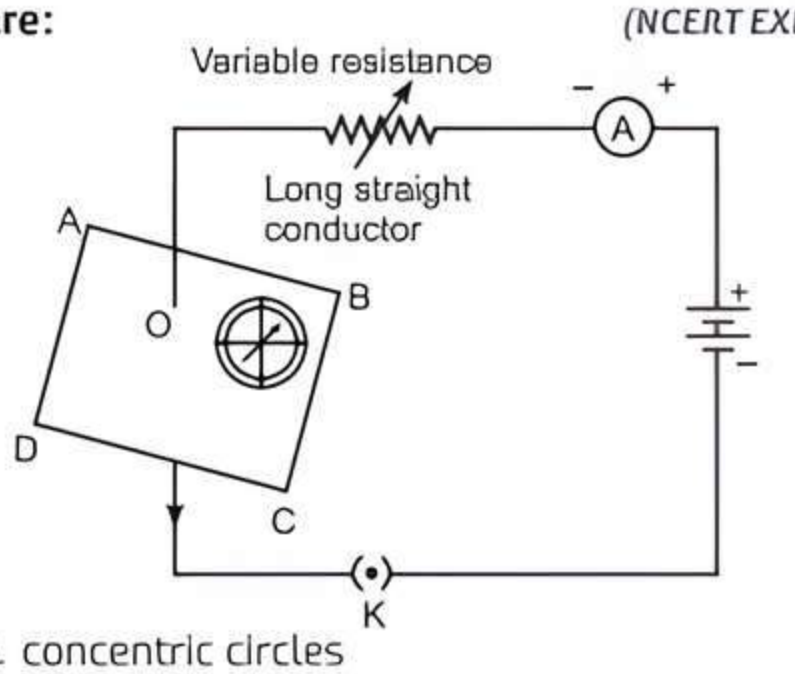
Q 1. Magnetic field is produced by the flow of current in a straight wire. The phenomenon was discovered by:

a. Faraday b. Fleming c. Maxwell d. Oersted

Q 2. By which instrument, the presence of magnetic field be determined?

a. Magnetic needle b. Ammeter
c. Galvanometer d. Voltmeter

Q 3. If the key in the arrangement is taken out (the circuit is made open) and magnetic field lines are drawn over the horizontal plane *ABCD*, the lines are: *(NCERT EXEMPLAR)*



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

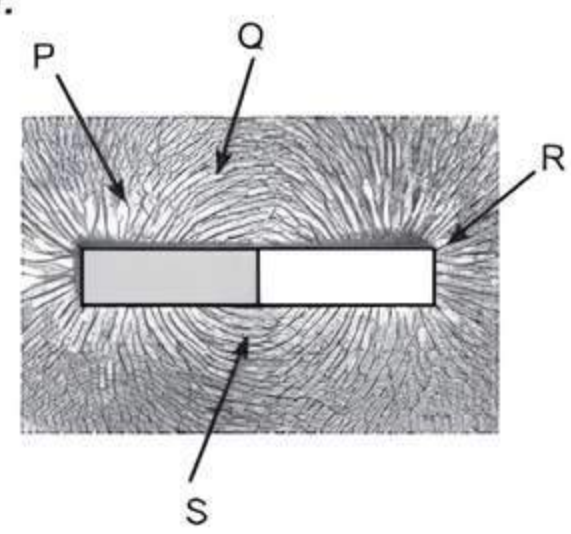
Q 4. Choose the incorrect statement from the following regarding magnetic lines of field. *(NCERT EXEMPLAR)*

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

Q 5. Two magnetic field lines:

a. intersect at neutral point
b. never intersect each other
c. intersect near north pole or south pole
d. intersect at the mid point of the magnet

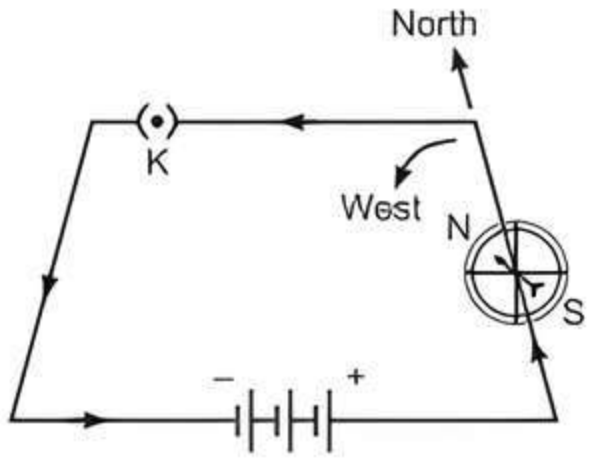
Q 6. A student places some iron filings around a magnet. The iron filings arrange themselves as shown in image:



The student labelled four different regions around the magnet. Where would the magnetic field be the strongest?

a. *P* b. *Q* c. *R* d. *S*

Q 7. A thick copper wire carries current due north placed parallel to and over a compass needle as shown in figure:



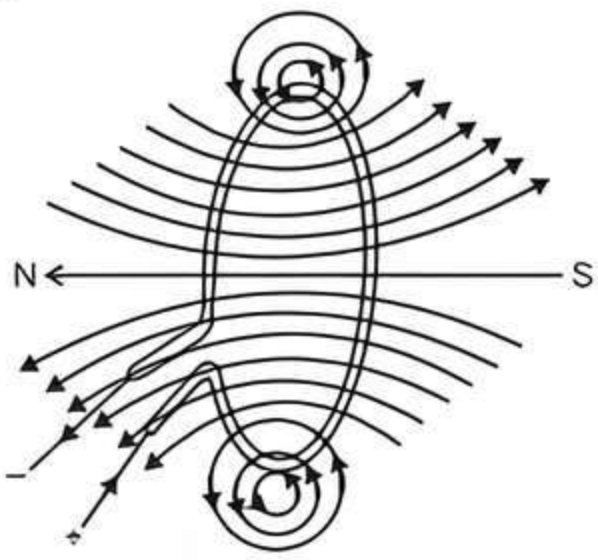
If the direction of current is changed from north to south, the needle will turn towards:

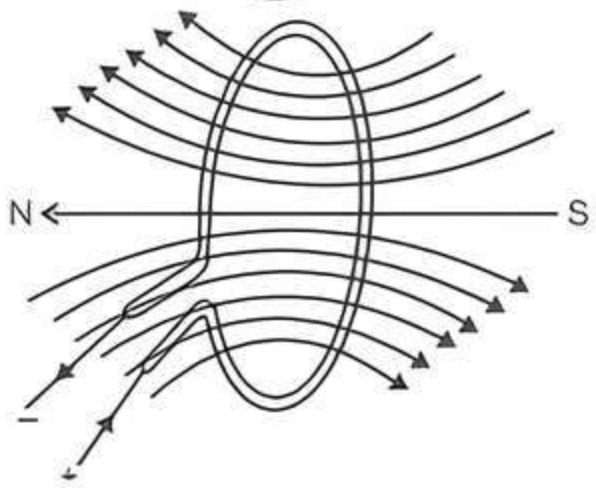
a. west b. north c. south d. east

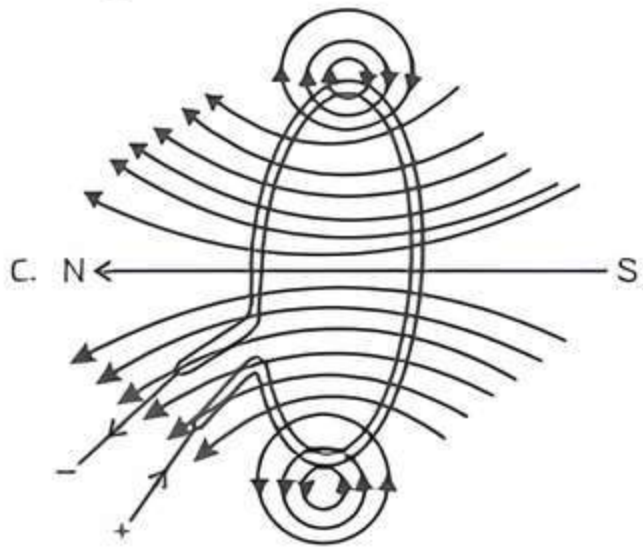
Q 8. Which of the following pattern correctly describes the magnetic field around a long straight current carrying wire? *(CBSE SQP 2022-23)*

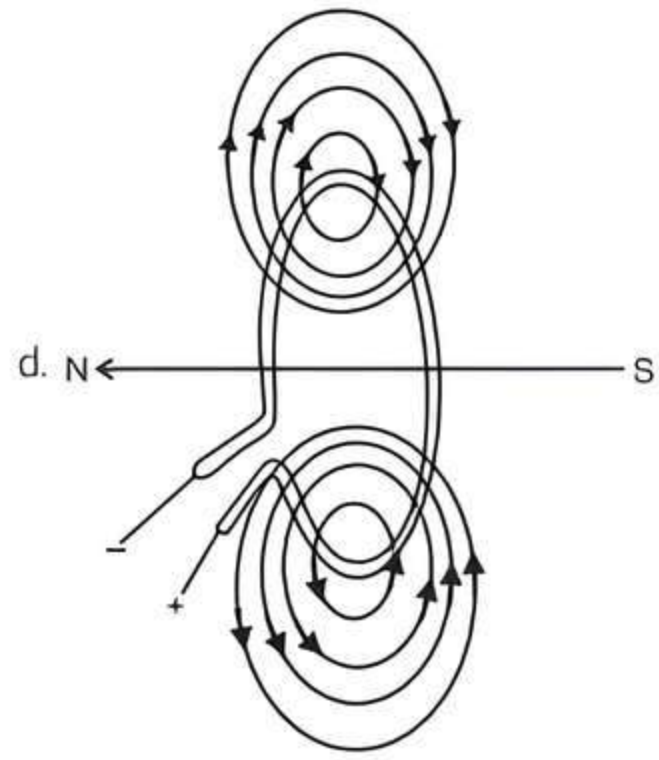
a. Straight lines perpendicular to the wire
b. Straight lines parallel to the wire
c. Radial lines originating from the wire
d. Concentric circles centred around the wire

Q 9. The correct pattern of magnetic field lines of the field produced by a current carrying circular loop is: *(CBSE 2023)*

a.


b.


c.


d.


Q 10. The factor/factors on which magnetic field strength produced by current carrying solenoid depends is/are:

a. magnitude of current
b. number of turns
c. nature of core material
d. All of the above

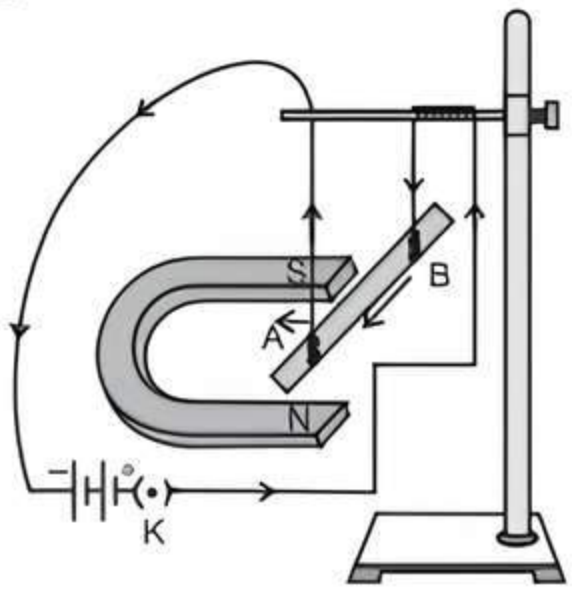
Q 11. The magnetic field of solenoid will not increase when:

a. the magnitude of current will increase
b. a soft iron core is inserted inside the solenoid
c. a soft aluminium core is inserted inside the solenoid
d. the conductor is kept closed

Q 12. The most suitable material for making the core of an electromagnet is:

a. steel b. iron
c. soft iron d. aluminium

Q 13. The displacement of the rod is larger when the angle between direction of current and magnetic field is:

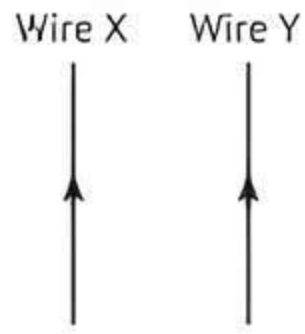


a. 30° b. 45° c. 90° d. 60°

Q 14. A magnetic field exerts no force on:

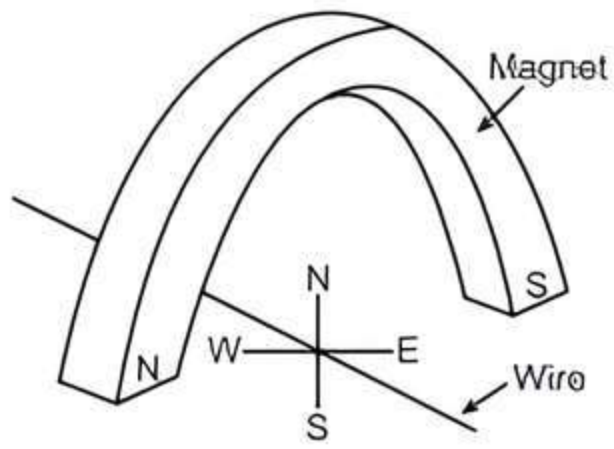
a. a stationary electric charge
b. a magnet
c. an electric charge moving perpendicular to its direction
d. an unmagnetised iron bar

Q 15. The long current-carrying wires are arranged in parallel as shown. What is the direction of the magnetic force on each wire?



	Wire X	Wire Y
a.	To the right	To the right
b.	To the left	To the left
c.	To the left	To the right
d.	To the right	To the left

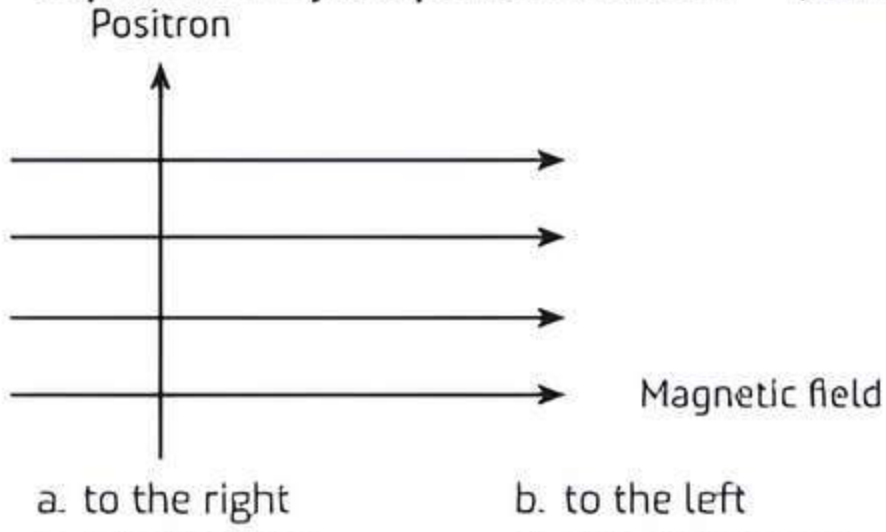
Q 16. A copper wire is held between the poles of a magnet.



The current in the wire can be reversed. The pole of the magnet can also be changed over. In how many of the four directions shown can the force act on the wire? *(CBSE SQP 2022-23)*

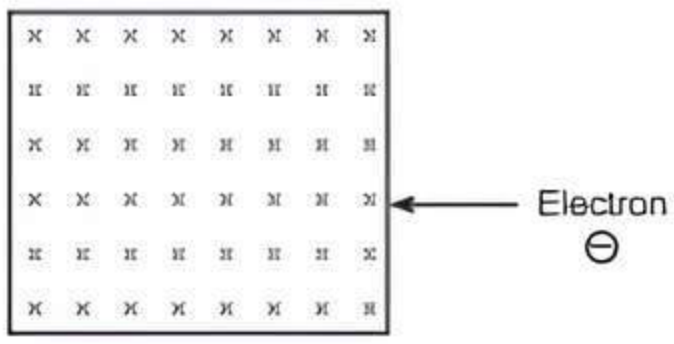
a. 1 b. 2 c. 3 d. 4

Q 17. A positron enters a uniform magnetic field at right angles to it as shown. The direction of force experienced by the positron will be: *(CBSE 2023)*



a. to the right b. to the left
c. Into the page d. out of the page

Q 18. An electron is entering a region of magnetic field as shown. Given that the magnetic field direction is into the paper. In which direction will the deflection of the electron occur?



a. Into the paper
b. Out of the paper
c. Towards the bottom of the paper
d. Towards the top of the paper

Q 19. At the time of short circuit, the current in the circuit:

a. vary continuously b. reduces considerably
c. Increases heavily d. does not change

Q 20. When a fuse is rated at 8 A, it means:

a. it will work only if current is 8 A
b. it will burn if current exceeds 8 A
c. it will not work if current is less than 8 A
d. it has a resistance of 8 Ω

Assertion & Reason Type Questions

Directions (Q. Nos. 21-27): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 21. Assertion (A): Magnetic field lines do not intersect each other.

Reason (R): Magnetic field lines are imaginary lines, the tangent to which at any point gives the direction of the field at that point. *(CBSE 2023)*

Q 22. Assertion (A): A compass needle is placed near a current carrying wire. The deflection of the compass needle decreases when the magnitude of the current in the wire is increases.

Reason (R): The strength of a magnetic field at a point near the conductor increases on increasing the current. *(CBSE SQP 2023-24)*

Q 23. Assertion (A): On freely suspending a current-carrying solenoid, it comes to rest in Geographical N-S direction.

Reason (R): One end of current-carrying straight solenoid behaves as a North pole and the other end as a South pole, just like a bar magnet. *(CBSE SQP 2022-23)*

Q 24. Assertion (A): A solenoid tends to expand, when a current passes through it.

Reason (R): Two straight parallel metallic wires carrying current in same direction repel each other.

Q 25. Assertion (A): A current carrying straight conductor experiences a force when placed perpendicular to the direction of magnetic field.

Reason (R): The net charge on a current carrying conductor is always zero. *(CBSE 2023)*

Q 26. Assertion (A): In Fleming's left-hand rule, the direction of magnetic field, force and current are mutually perpendicular.

Reason (R): Fleming's left-hand rule is applied to measure the induced current.

Q 27. Assertion (A): A fuse in a circuit prevents damage to the appliances and the circuit due to overloading.

Reason (R): Overloading occurs when the live wire and the neutral wire come into direct contact.

Answers

1. (d) Oersted

Knowledge BOOSTER

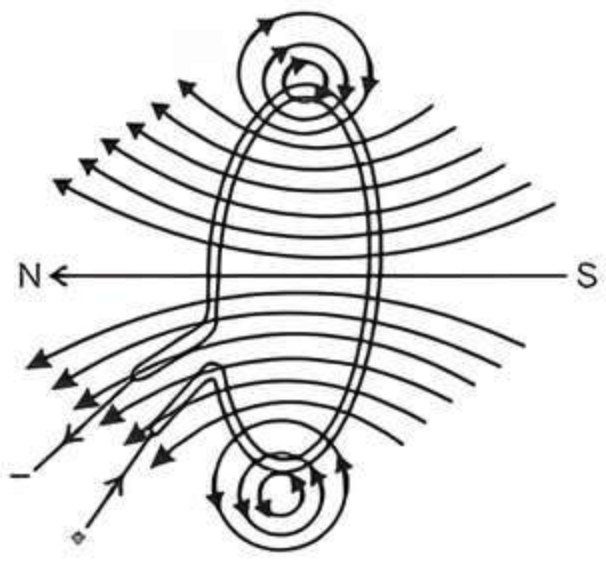
Hans Christian Oersted was the first who discovered that a compass needle got deflected when an electric current is passed through a metallic wire placed nearby.

2. (a) Magnetic needle
3. (c) If the key is taken out, then there will be no current in the circuit. *i.e.*, no magnetic field due to circuit. So, only earth magnetic field will be present and field due to it will be stralght lines parallel to each other.

TiP

The needle of a compass is a magnet.

4. (c) If magnetic field lines are parallel and equidistant then, they represent zero field strength.
5. (b) never intersect each other
6. (c) *R*
7. (d) east
8. (d) Concentric circles centred around the wire
9. (c)



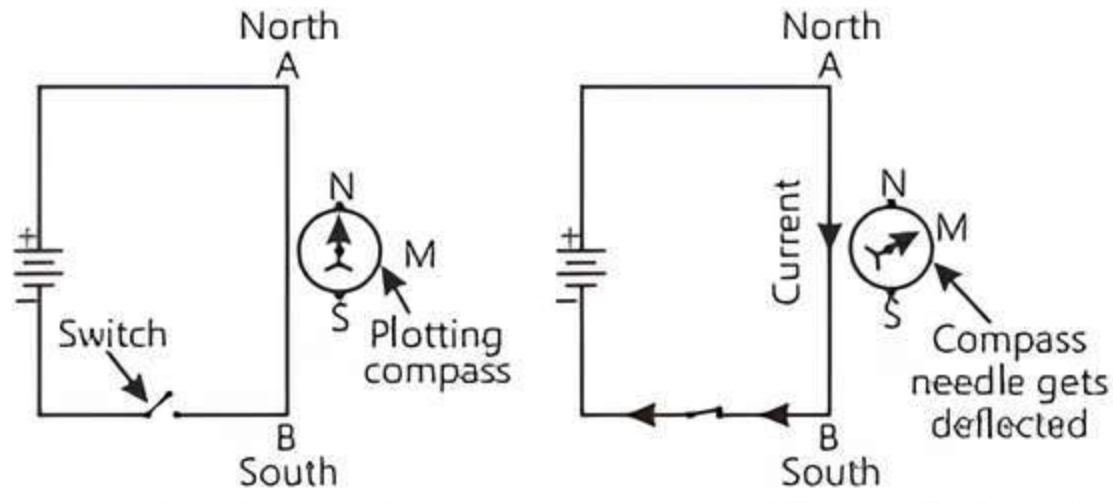
10. (d) All of the above
11. (b) a soft iron core is inserted inside the solenoid
12. (c) soft iron
13. (c) Maximum force is experienced when the current and magnetic fields are perpendicular to each other.
14. (a) a stationary electric charge
15. (d) **Wire *X*** — To the right. **Wire *Y*** — To the left
16. (b) 2 (Either north or south)
17. (c) into the page
18. (d) Towards the top of the paper.
19. (c) increases heavily
20. (b) it will burn if current exceeds 8 A
21. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
22. (d) Assertion (A) is false but Reason (R) is true.
23. (a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
24. (d) Solenoid tends to contract as the turns of the solenoid attract each other when current flows through them in the same direction.
25. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is snot the correct explanation of Assertion (A).
26. (c) Assertion (A) is true but Reason (R) is false.
27. (b) Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

Case Study Based Questions

Case Study 1

Oersted, one of the leading scientists of the 19th century discovered that a compass needle got deflected when an electric current is passed through a metallic wire placed nearby.

The following experiment is shown by a teacher to describe Oersted's experiment to his students.



Read the above passage carefully and give the answer of the following questions:

Q 1. Oersted experiment explained ..... effect of current.

a. electric field
b. magnetic field
c. Both a. and b.
d. None of these

Q 2. In the earth's magnetic field alone, the compass needle rest along in which direction?

a. East-west
b. North-east
c. South-north
d. No fixed direction

Q 3. By which instrument the presence of magnetic field at a point can be detected?

a. A strong magnet
b. A solenoid
c. A compass needle
d. A current carrying line

Q 4. On reversing the direction of current in a wire, the magnetic field produced by it:

a. gets reversed in direction
b. increases in strength
c. decreases in strength
d. remains unchanged in strength and direction

Q 5. **How can you find the direction of magnetic field from a magnetic field line?**

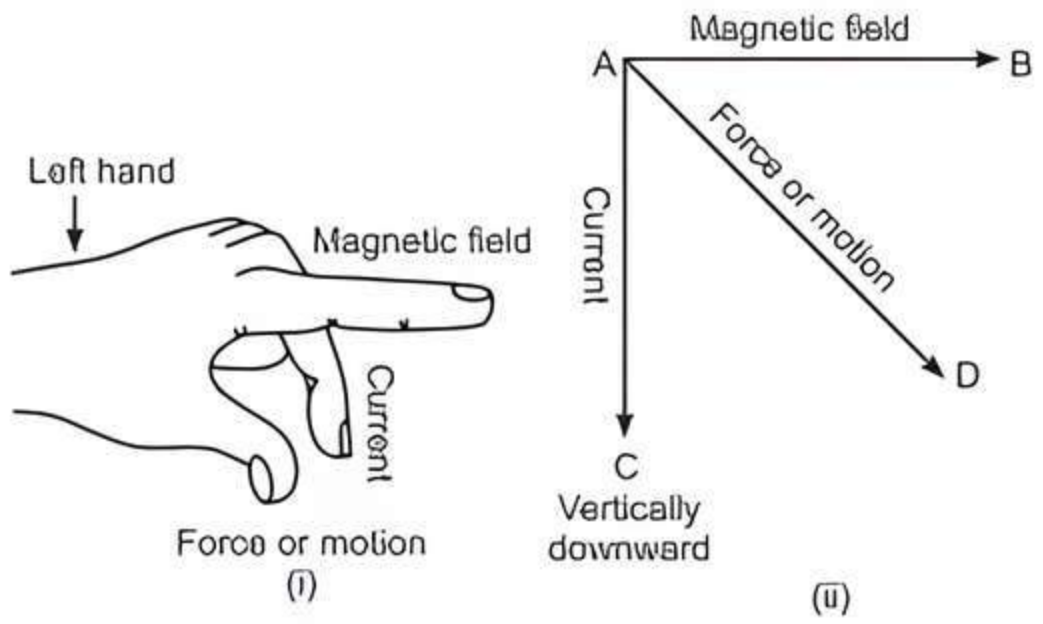
a. We can't say from magnetic field line
b. Along the perpendicular to the field line
c. Along the parallel to the field line
d. Along the tangent at any point of the field line

Answers

1. (b) magnetic field
2. (c) South-north
3. (c) A compass needle
4. (a) gets reversed in direction
5. (d) Along the tangent at any point of the field line

Case Study 2

Andre Marie Ampere suggested that a magnet must exert an equal and opposite force on a current carrying conductor, which was experimentally found to be true. But we know that current is due to charges in motion. Thus, it is clear that a charge moving in a magnetic field experience a force, except when it is moving in a direction parallel to it. If the direction of motion is perpendicular to the direction of magnetic field, the magnitude of force experienced depends on the charge, velocity (v), strength of magnetic field (B), and sine of the angle between v and B. Direction of magnetic force is given by Fleming's left-hand rule.



Read the above passage carefully and give the answer of the following questions:

Q 1. **If an electron is travelling horizontally towards east, a magnetic field in vertically downward direction exerts a force on the electron along:**

a. east b. west c. north d. south

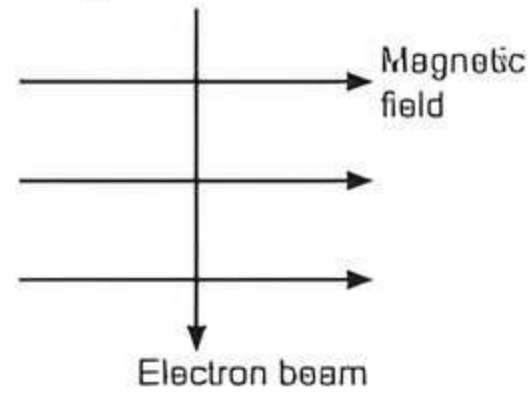
Q 2. **If a charged particle is moving along a magnetic field line, the magnetic force on the particle is:**

a. along its velocity
b. opposite to its velocity
c. perpendicular to its velocity
d. zero

Q 3. **A magnetic field exerts no force on:**

a. a stationary electric charge
b. a magnet
c. an electric charge moving perpendicular to its direction
d. an unmagnetised iron bar

Q 4. **An electron beam enters a magnetic field at right angle to it as shown in the figure. The direction of force acting on the electron beam will be:**



a. to the left b. to the right
c. to the page d. out of the page

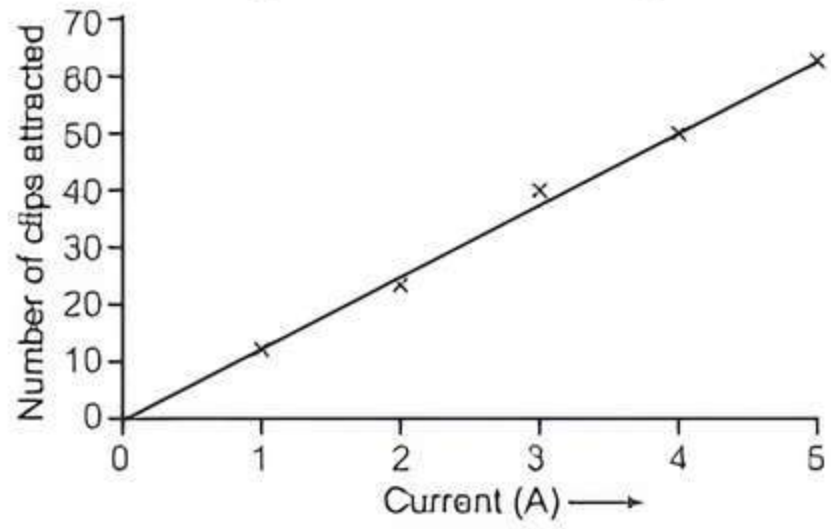
Answers

1. (d) Fleming's left-hand rule is used to determine the direction of force on electron *i.e.*, in south direction.
2. (d) The angle between velocity and magnetic field is zero. Therefore, magnetic force on the particle is zero.
3. (d) an unmagnetised iron bar
4. (c) to the page

Case Study 3

An electromagnet is a magnet consisting of a long coil of insulated copper wire wrapped around a soft iron core that is magnetised only when electric current is passed through the coil. Soft iron is used as core of an electromagnet because soft iron loses all of its magnetism when current in the coil is switched off. The strength of an electromagnet is depends on a few factors such as number of turns in the coil, current flowing in the coil, etc.

The following graph is obtained by a student while doing an experiment to see how current affects the strength of an electromagnet.



Read the above passage carefully and give the answer of the following questions.

Q 1. **Name two factors on which the strength of a magnetic field of an electromagnet depends.**

Q 2. **Which kind of energy change takes place in an electromagnet?**

Q 3. **Which material is used to make electromagnets and why?**

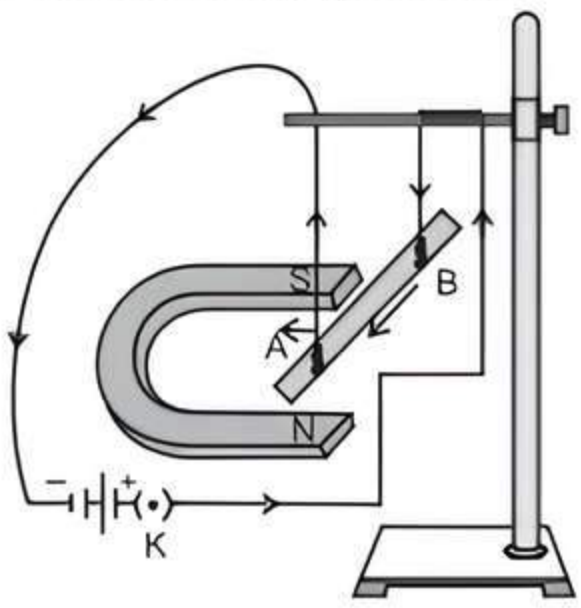
Q 4. **Why soft iron is used as a core of an electromagnet?**

Answers

1. The strength of an electromagnet depends on the number of turns in the coils and the strength of the current passing through the coil.
2. The energy change that takes place in an electromagnet is electrical energy to magnetic energy.
3. Soft iron is used to make electromagnets because soft iron loses all of its magnetism when current in the coil is switched off.
4. Because soft iron loses all of its magnetism when current in the coil is switched off.

Case Study 4

A student was asked to perform an experiment to study the force on a current carrying conductor in a magnetic field. He took a small aluminium rod *AB*, a strong horse-shoe magnet, some connecting wires, a battery and a switch and connected them as shown. He observed that on passing current, the rod gets displaced. On reversing the direction of current, the direction of displacement also gets reversed. On the basis of your understanding of this phenomenon, answer the following questions:



Read the above passage carefully and give the answer of the following questions:

Q 1. Why does the rod get displaced on passing current through it?

Q 2. State the rule that determines the direction of the force on the conductor AB.

Q 3. (i) If the U shaped magnet is held vertically and the aluminium rod is suspended horizontally with its end *B* towards due north, then on passing current through the rod from B to A as shown, in which direction will the rod be displaced?

(ii) Name any two devices that use current carrying conductors and magnetic field.

Or

Draw the pattern of magnetic field lines produced around a current carrying straight conductor held vertically on a horizontal cardboard. Indicate the direction of the field lines as well as the direction of current flowing through the conductor.

(CBSE 2022 Term-2)

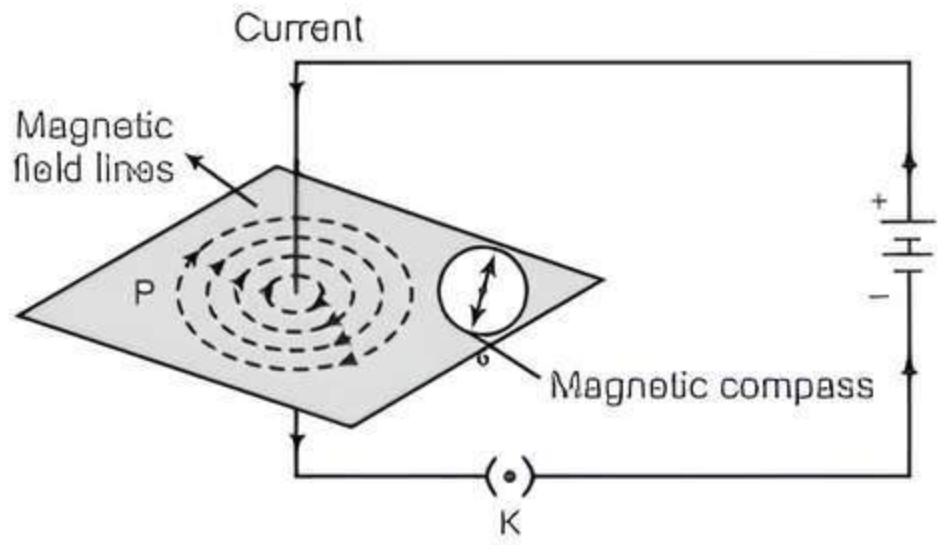
Answers

1. When a current-carrying conductor is placed in a magnetic field, a mechanical force is exerted on the conductor which makes rod displaced.
2. Fleming's left hand rule determines the direction of the force on the conductor AB.

   According to this rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If the first finger point 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.
3. (i) Towards the left.

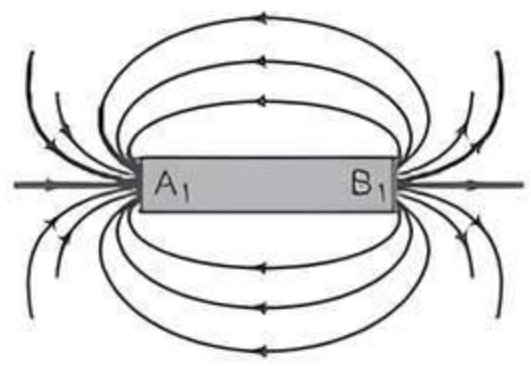
   (ii) Electric motor and electric generator.

Or



Very Short Answer Type Questions

Q 1. Identify the poles of the magnet in the given figure:



Ans. B_1 is north pole and A_1 is south pole because the field lines emerge from north pole and merge at the south pole.

Q 2. State the direction of magnetic field inside a bar magnet.

Ans. Inside a bar magnet, the direction of magnetic field is from its south pole to its north pole.

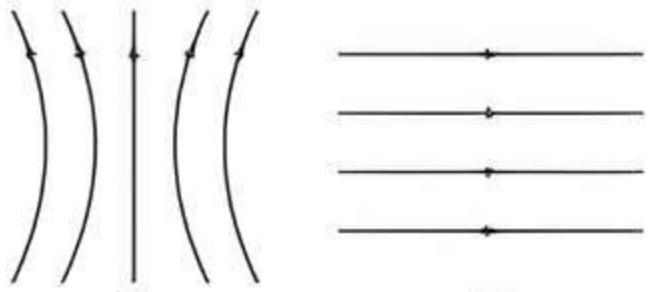
Q 3. A magnetic compass shows a deflection when placed near a current carrying wire. How will the deflection of the compass get affected if the current in the wire is increased? *(NCERT EXEMPLAR)*

Ans. The deflection increases because the strength of magnetic field is directly proportional to the magnitude of current passing through the straight conductor.

Q 4. What does the direction of thumb indicate in the right-hand thumb rule? *(NCERT EXEMPLAR)*

Ans. The thumb indicates the direction of current in the straight conductor held by curled fingers.

Q 5. Identify the type of magnetic field represented by the magnetic field lines given below and name the type of conductors which can produce them.

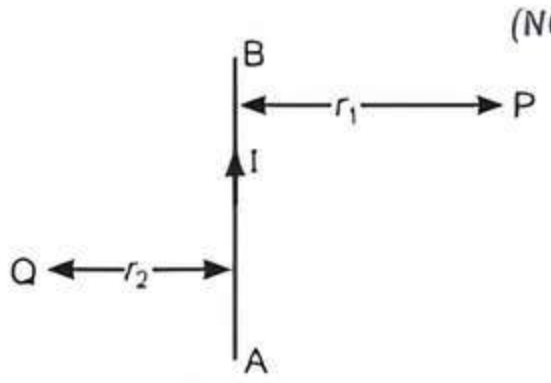


(i) (ii)

Ans. (i) Magnetic field lines of a current carrying circular loop.

(ii) Magnetic field lines in a solenoid.

Q 6. AB is a current carrying conductor in the plane of the paper as shown in figure. Given $r_1 > r_2$, where will the strength of the magnetic field be larger? *(NCERT EXEMPLAR)*



Ans. The strength of the magnetic field is larger at the point located closer *i.e.*, at *Q*.

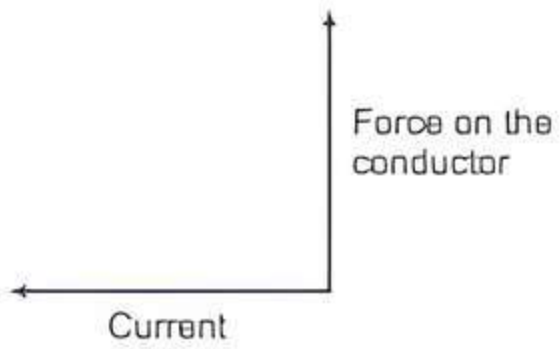
Q 7. What does the divergence of magnetic field lines near the ends of a current carrying straight solenoid indicate? *(NCERT EXEMPLAR)*

Ans. The divergence indicates the decrease in strength of magnetic field near and beyond the ends of the solenoid.

Q 8. When is the force experienced by a current carrying conductor placed in a magnetic field is maximum?

Ans. A current carrying conductor experience maximum force in a magnetic field when the direction of current is perpendicular to the magnetic field.

Q 9. State the direction of magnetic field in the following case.



Ans. The direction is perpendicular to the plane of paper in the outward direction by using Fleming's left-hand rule.

Short Answer Type-I Questions

Q 1. 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:

(i) Magnitude of electric current is increased.

(ii) The compass needle is displaced away from the conductor. *(CBSE 2019)*

Ans. (i) Magnetic field strength is directly proportional to the electric current, so the deflection of the needle increases.

(ii) Magnetic field strength is inversely proportional to the distance from the wire, so the deflection of the needle decreases.

Q 2. It is established that an electric current through a conductor produces a magnetic field around it. Is there a similar magnetic field produced around a thin beam on moving (i) α- particles, (ii) neutrons? Justify your answer in each case. *(CBSE 2019)*

Ans. (i) α- particles, being positively charged, constitutes a current in the direction of motion. So, a magnetic field is produced.

(ii) The neutrons, being electrically neutral, constitute no current. So, no magnetic field is produced.

Q 3. List four properties of magnetic field lines. *(CBSE 2019)*

Ans. Four properties of magnetic field lines are as follows:

(i) The field lines emerge from north pole and merge at south pole.

(ii) The magnetic field lines are stronger at poles.

(iii) The magnetic field lines do not cross /intersect each other.

(iv) The magnetic field lines are closed curves.

COMMON ERROR

Students often repeat the same properties in different words.

Q 4. When is the force experienced by a current carrying straight conductor placed in a uniform magnetic field:

(i) maximum

(ii) minimum? *(CBSE 2022 Term-2)*

Ans. **(i) Maximum:** When the current carrying conductor is placed perpendicular to magnetic field.

(ii) Minimum: When the current carrying conductor is placed parallel to the magnetic field.

Q 5. (i) Name the poles P, Q, R and S of the magnets in the following figures 'a' and 'b'

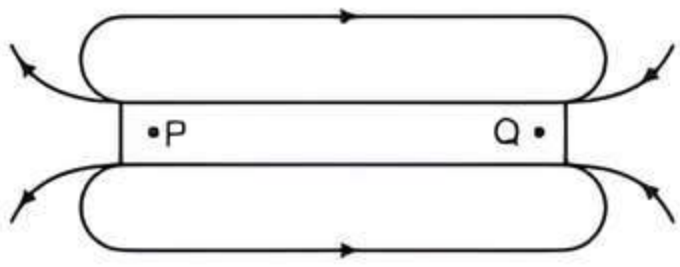


Figure 'a'

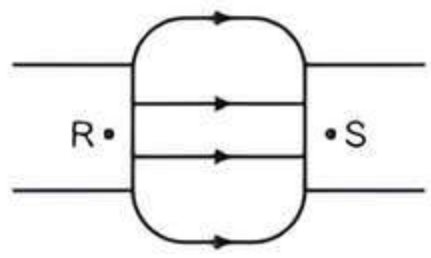


Figure 'b'

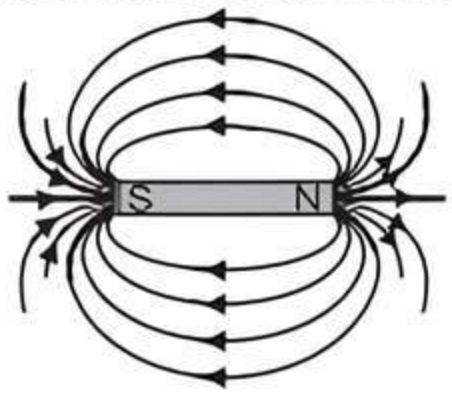
(ii) State the inference drawn about the direction of the magnetic field lines on the basis of these diagrams. *(CBSE 2022 Term-2)*

Ans. (i) P → North pole
Q → South pole
R → North pole
S → South pole

(ii) The magnetic field lines emerge from north pole and merge at the south pole.

Q 6. Draw magnetic field lines around a bar magnet. *(CBSE 2019)*

Ans. Magnetic field lines around a bar magnet:

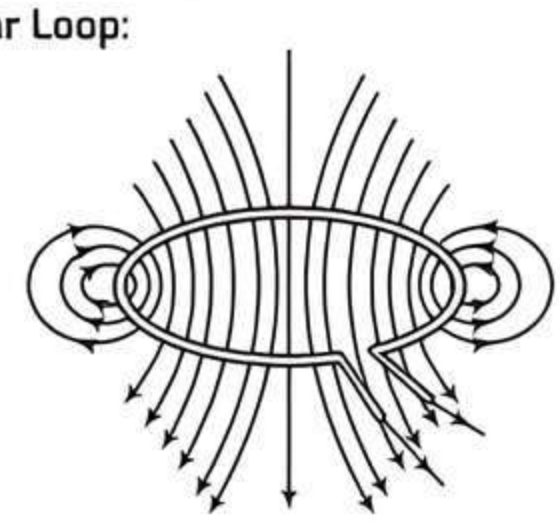


COMMON ERROR

Many students fail to show the correct direction of magnetic field.

Q 7. Consider a circular loop of thick copper wire lying horizontally on a table. Let the current pass through the loop anticlockwise. Draw the magnetic field lines to show the direction and the pattern of the magnetic field inside and outside the loop. *(CBSE 2023)*

Ans. Magnetic Field Lines Due to a Current Carrying Circular Loop:



Q 8. 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 EXEMPLAR)*

Ans. Strength of the magnetic field decreases as distance increases. This is indicated by the decrease in degree of closeness of the field lines.

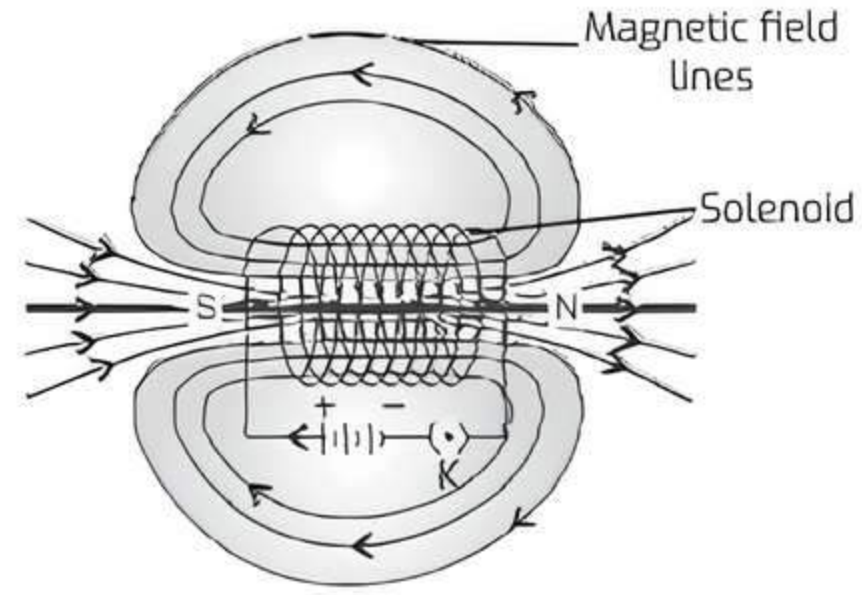
Q 9. Draw magnetic field lines in and around a current carrying straight solenoid. *(CBSE 2019)*

Ans.

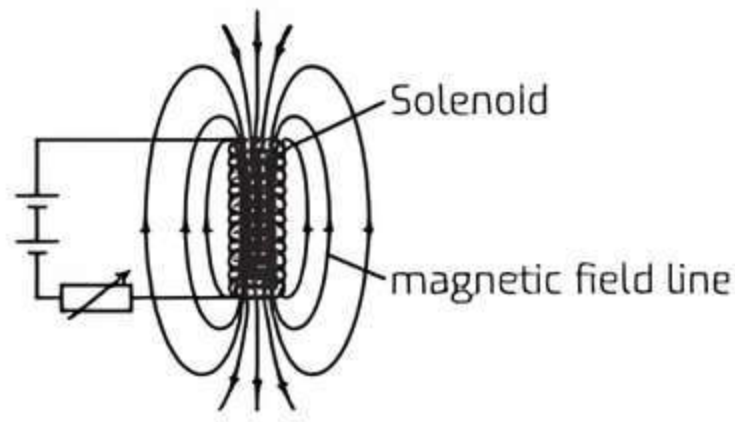
TiP

Students should draw neat diagrams along with the arrows indicating the direction of magnetic field.

Magnetic field lines in and around a current carrying straight solenoid:



Q 10. A circuit contains a battery, a variable resistor and a solenoid. The figure below show the magnetic field pattern produced by the current in the solenoid.



(i) State how the magnetic field pattern indicates regions where the magnetic field is stronger?

(ii) What happens to the magnetic field when the current in the circuit is reversed?

(CBSE SQP 2023-24)

Ans. (i) Relative closeness of field lines indicates the strength of magnetic field. Since field lines are crowded around the ends of the solenoid, hence these are the regions of strongest magnetism.

(ii) The direction of the field will also be reversed.

Q 11. Under what conditions permanent electromagnet is obtained if a current carrying solenoid is used? *(NCERT EXEMPLAR)*

Ans. The conditions to obtain permanent electromagnet if a current carrying solenoid is used are:

(i) The current through the solenoid should be direct current.

(ii) The rod inside is made of a magnetic material such as steel.

Q 12. 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 EXEMPLAR)*

Ans. Fuse is used for protecting appliances from short-circuiting or overloading.

When a fuse with defined rating for a particular appliance is replaced by one with larger rating, it does not blow off and the appliance is damaged due to larger current passing through it.

Q 13. Differentiate between overloading and short-circuiting.

Ans. Difference between overloading and short-circuiting:

S.No.	Basis of Difference	Overloading	Short-circuiting
1.	Cause	It occurs when too many appliances are connected to a single socket.	It occurs when live wire comes in contact with the neutral wire.
2.	Amount of current	Low amount of current flows through the circuit as compared to short-circuit.	High amount of current flows through the circuit.

TiP

Always learn the differences in tabular form for easy remembrance than in paragraph form.

Short Answer Type-II Questions

Q 1. A student fixes a white sheet of paper on a drawing board. He places a bar magnet in the centre and sprinkles some iron fillings uniformly around the bar magnet. Then he taps gently and observes that iron filings arrange themselves in a certain pattern.

(i) Why do iron filings arrange themselves in a particular pattern?

(ii) Which physical quantity is indicated by the pattern of field lines around the bar magnet?

(iii) State any two properties of magnetic field lines. *(CBSE SQP 2022-23)*

Ans. (i) When iron filings are placed in a magnetic field around a bar magnet, they behave like tiny magnets. The magnetic force experienced by these tiny magnets make them rotate and align themselves along the direction of field lines.

(ii) The physical property indicated by this arrangement is the magnetic field produced by the bar magnet.

(iii) Two properties of magnetic field lines are as follows:

(a) Magnetic field lines never intersect.

(b) Magnetic field lines are closed curves.

Q 2. What are magnetic field lines? Justify the following statements:

(i) Two magnetic field lines never intersect each other.

(ii) Magnetic field lines are closed curves. *(CBSE 2015)*

Ans. Magnetic field lines are imaginary lines along which the north magnetic pole tends to move in a magnetic field.

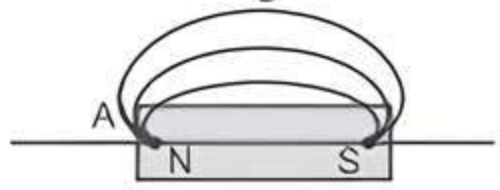
(I) The magnetic lines of force never intersect (or cross) each other. If they do so, then at the point of intersection, there will be two different directions of the same magnetic field, which is not possible.

(II) Magnetic field lines are closed continuous curves. These lines emerge out from the north pole of a bar magnet and merge into its south pole. Inside the magnet, they move from south pole to north pole.

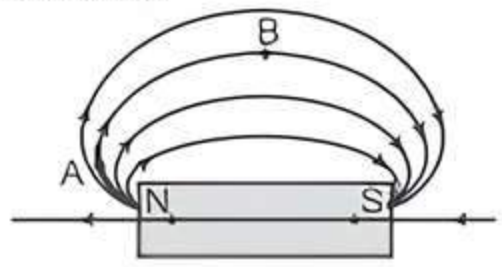
TiP

Definitions and explanations of technical terms must be precise and complete.

Q 3. Magnetic field lines are shown in the given diagram. A student makes a statement that the magnetic field at 'A' is stronger than at 'B'. Justify this statement. Also redraw the diagram and mark the direction of magnetic field lines. *(CBSE 2019)*



Ans. The relative strength of the magnetic field is shown by the degree of closeness of the field lines. The degree of closeness is more at A than at B. Therefore, the magnetic field is stronger at A where the field lines are crowded.



Q 4. A compass needle is placed near a current carrying wire. State your observations for the following cases and give reasons for the same in each case:

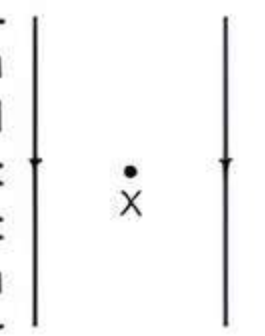
(i) Magnitude of electric current in wire is increased.

(ii) The compass needle is displaced away from the wire. *(CBSE SQP 2022-23)*

Ans. (i) The deflection in the compass needle increases as magnetic field of the current carrying conductor is directly proportional to current flowing through it.

(ii) The deflection in the needle decreases as the magnetic field is inversely proportional to the perpendicular distance from the wire.

Q 5. The following diagram shows two parallel straight conductors carrying same current. Copy the diagram and draw the pattern of the magnetic field lines around them showing their directions. What is the magnitude of magnetic field at a point 'X' which is equidistant from the conductors? Give justification for your answer. *(CBSE 2019)*

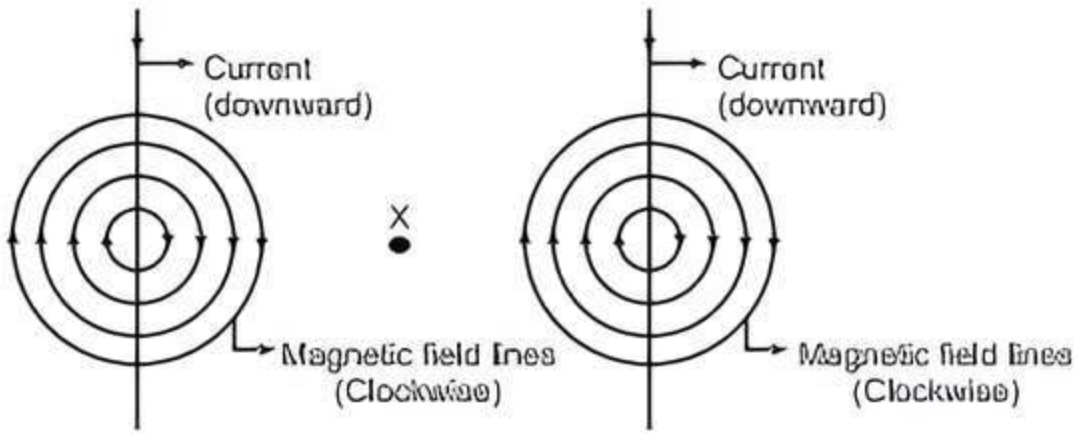


Ans.

TiP

Clear your knowledge on this concept and practice drawing the correct pattern of magnetic field along with the arrows indicating the direction of magnetic field.

Applying right-hand thumb rule, as both the wires have current flowing in downward direction, hence the magnetic field will be clockwise for both of them as shown in the figures.



At point X, the magnetic field due to both conductors has opposite directions and as the point is equidistant from the conductors so the net magnitude of the magnetic field at point X will be zero.

Q 6. State right-hand thumb rule to determine the direction of magnetic field around a current carrying conductor. Apply this rule to find the direction of magnetic field inside and outside a circular loop of wire lying in the plane of a table and current is flowing through it clockwise.

(CBSE 2019)

Ans. Right-hand thumb rule states that if a current carrying conductor is held in the right-hand in such a way that thumb indicates the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor.

The magnetic field will be directed perpendicular into the plane of table inside the circular loop.

The magnetic field will be directed perpendicular outside the plane of table for a point outside the circular loop.

Hence, the direction of magnetic field lines inside the loop will be entering into the table while outside the loop, they will be emerging from the table.

COMMON ERROR

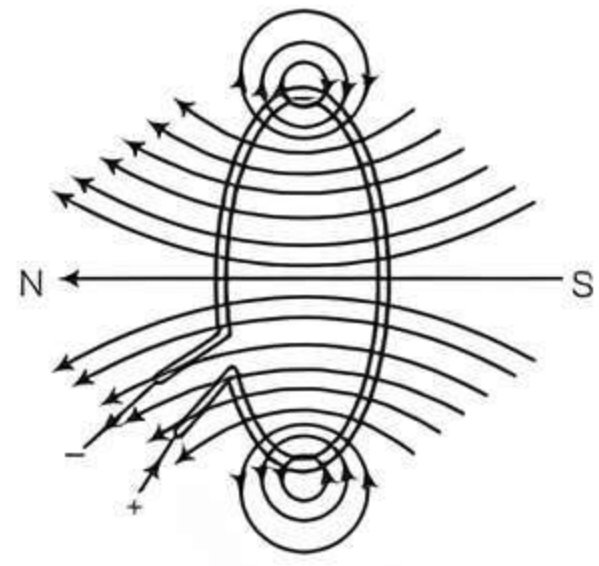
Students do not learn the statement of rule properly or identify incorrect rules.

Q 7. (i) Draw the pattern of magnetic field lines due to a magnetic field through and around a current carrying circular loop.

(ii) Name and state the rule to find out the direction of magnetic field inside and around the loop.

(CBSE 2020, 22 Term-2)

Ans. (i) Magnetic field lines through and around a current carrying circular loop:



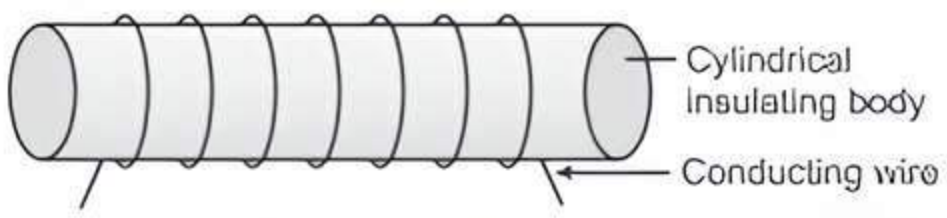
(ii) Right-hand thumb rule is used to find the direction of magnetic field inside and around a current carrying circular loop.

It states that if a current carrying conductor is held in the right-hand in such a way that thumb indicates the direction of current, then the curled finger indicates the direction of magnetic field lines around conductor.

Q 8. What is meant by solenoid? How does a current carrying solenoid behave? Give its main use.

(CBSE 2015, 16)

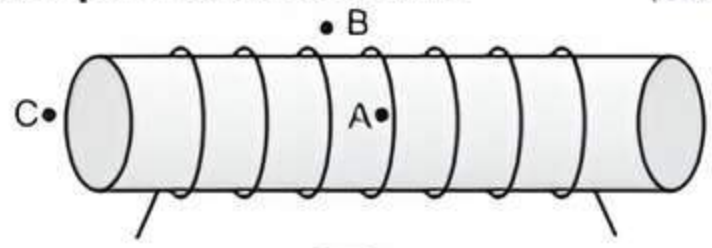
Ans. Solenoid is a coil of many circular turns of insulated copper wire wound on a cylindrical insulating body (*i.e.*, cardboard, etc.) such that its length is greater than its diameter.



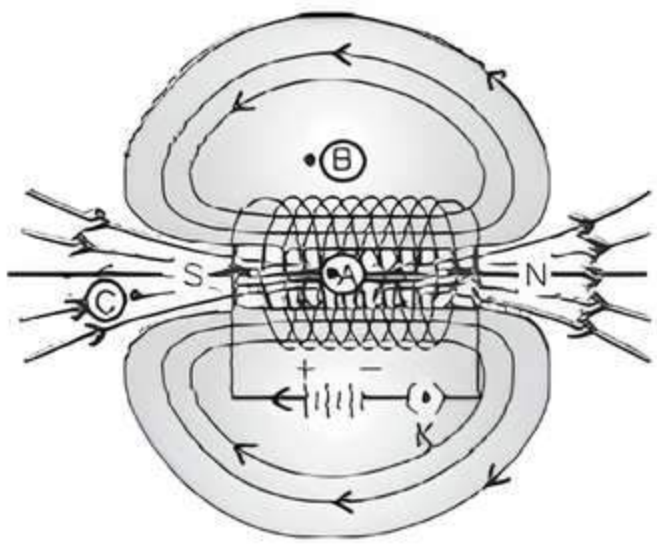
When current is passed through the solenoid, the magnetic field line pattern resembles exactly with a bar magnet with the fixed polarity, *i.e.*, north and south pole at its end. Hence, the current carrying solenoid behaves like a bar magnet.

Use of a Current Carrying Solenoid: A temporary magnet (electromagnet) can be formed by the use of a solenoid.

Q 9. For the current carrying solenoid as shown below, draw magnetic field lines and giving reason, explain that out of the three points A, B and C at which point the field strength is maximum and at which point it is minimum? *(CBSE 2023, 15)*



Ans.



Outside the solenoid, the magnetic field is minimum. At the end point C of the solenoid, the magnetic field strength is half of that inside it. So, it will be minimum at point B and maximum at point A.

Q 10. Give reasons 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 solenold when suspended freely rests along a particular direction.

(iii) The burnt out fuse should be replaced by another fuse of identical rating. *(CBSE 2020)*

Ans. (I) Magnetic field lines diverge from N-pole and converge at S-pole because strength of magnetic field is higher near the poles.

(II) Current carrying solenold acts as a bar magnet which rests in North-south direction when suspended freely.

(iii) The burnt out fuse cannot be reused. Also, if a fuse with larger rating is used, the fuse wire will melt and hence would fail to serve the required purpose. So, new fuse of same rating should be used for electrical safety.

Q 11. (i) What is the function of earth wire in electrical instruments?

(ii) Explain what is short circuiting of an electric supply?

(iii) What is the usual current rating of the fuse wire in the line to feed:

(a) lights and fans?

(b) appliances of 2 kW or more power?

Ans. (i) Earth wire is used for safety measure to ensure that any leakage of current in a metallic body does not give any serious shock to a user.

(ii) Short circuiting occurs when live and neutral wires of an electric circuit come into direct contact.

(III) The usual current rating of the fuse wire is:

(a) 5 A for light and fans

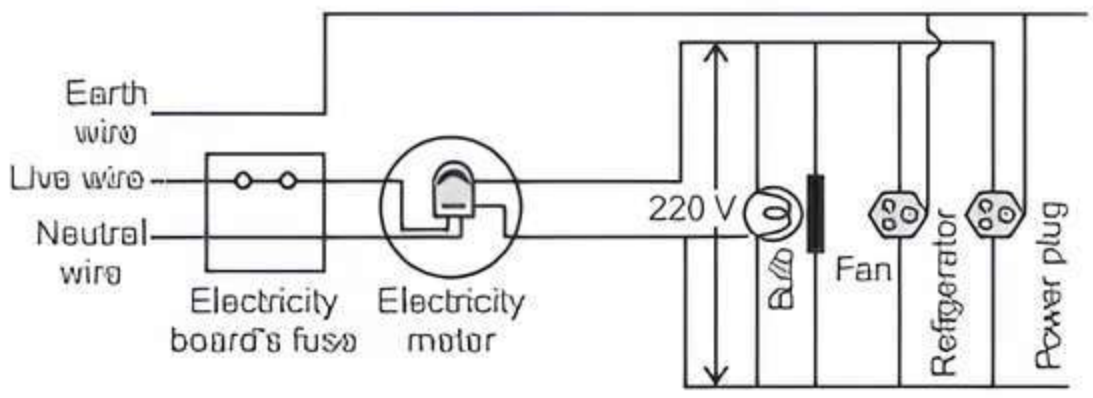
(b) 15 A for appliances of 2 kW or more power.

Q 12. Suppose your parents have constructed a two room house and you want that in the living room there should be a provision of one electric bulb, one electric fan, a refrigerator and a plug point for appliances of power up to 2 kW. Draw a circuit diagram showing electric fuse and earthing as safety devices.

Ans.

TiP

Draw correct and labelled circuit diagram. Marks will be deducted if all the parts of the circuit diagram are not correctly labelled.



Q 13. Anannya responded to the question: Why do electrical appliances with metallic bodies are connected to the mains through a three pin plug, whereas an electric bulb can be connected with a two pin plug?

She wrote: Three pin connections reduce heating of connecting wires.

(i) Is her answer correct or incorrect? Justify.

(ii) What is the function of a fuse in a domestic circuit? *(CBSE SQP 2023-24)*

Ans. (I) Anannya's answer is wrong. Electrical appliances with metallic bodies need an earth wire which provides a low resistance conducting path to the flow of current in case there is an accidental leakage of current through the conducting body of the appliances.

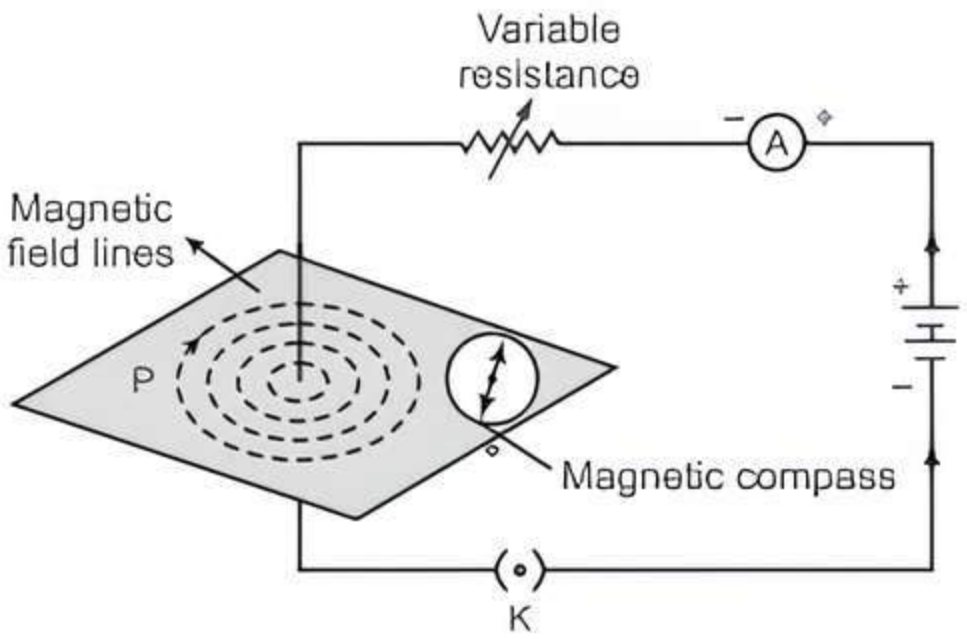
(ii) An electrical fuse is a safety device that operates to provide protection against the overflow of current in an electrical circuit. An important component of an electrical fuse is a metal wire or strip that melts when excess current flows through it.

Long Answer Type Questions

Q 1. (i) Draw magnetic field lines produced around a current carrying straight conductor passing through a cardboard. Name, state and apply the rule to mark the direction of these field lines.

(ii) How will the strength of the magnetic field change when the point where magnetic field is to be determined is moved away from the straight wire carrying constant current? Justify your answer. *(CBSE 2019)*

Ans. (I) To mark the direction of magnetic field lines, we use the right-hand thumb rule. According to this rule, if we hold a current carrying conductor in our right-hand such that thumb points towards the direction of current, the direction in which the fingers wrap the wire represent the direction of the magnetic field. As we can see in the figure that the current is going downwards, so the direction of magnetic field lines is clockwise

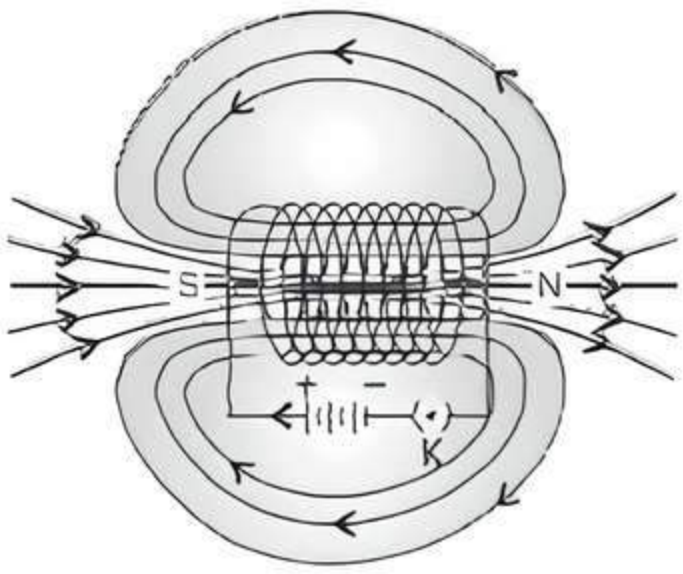


(ii) The strength of the magnetic field decreases when the point where magnetic field is to be determined is moved away from the straight wire carrying current because strength of the magnetic field is inversely proportional to the distance from the origin.

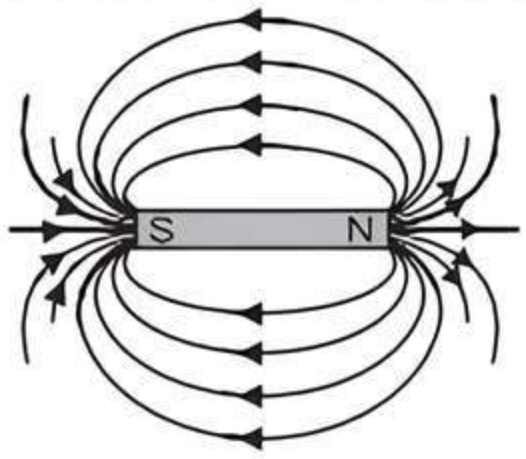
Q 2. What is a solenoid? Draw the pattern of magnetic field lines of (i) a current carrying solenoid and (ii) a bar magnet. List two distinguishing features between the two fields. *(CBSE 2019)*

Ans. A solenoid is a coil with many circular turns of insulated copper wire wrapped closely in the shape of a cylinder.

(I) Magnetic field lines of current carrying solenoid:



(ii) Magnetic field lines of a bar magnet:



COMMON ERROR

Students commit error in showing correct direction of magnetic field lines.

Distinguishing features between the two fields:

(i) The strength of magnetic field of the solenoid can be changed by changing current while the magnetic field strength due to bar magnet is constant.

(ii) Solenoid produces magnetic field as long as current flows in its coils while bar magnet produces a permanent magnetic field.

Q 3. (i) What is an electromagnet? List any two uses.

(ii) Draw a labelled diagram to show how an electromagnet is made.

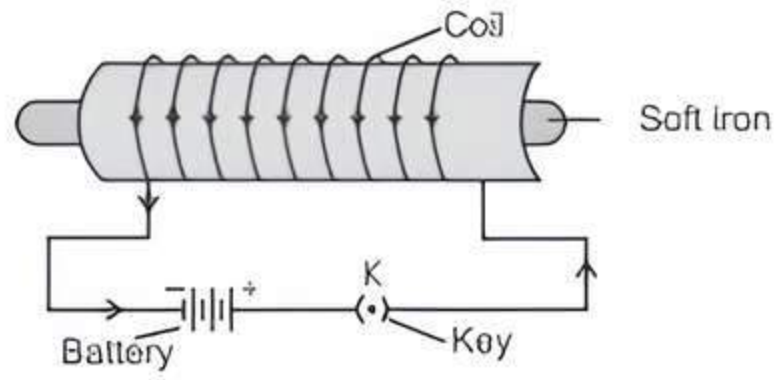
(iii) State the purpose of soft iron core used in making an electromagnet.

(iv) List two ways of increasing the strength of an electromagnet, if the material of the electromagnet is fixed. *(CBSE 2020)*

Ans. (I) An electromagnet refers to a magnetised solenoid which behaves like a magnet as long as electric current passes through it. An electromagnet consists of a long insulated copper wire wound around a soft iron core.

The electromagnets are used in electric motors, electric bells, loudspeakers, etc.

(ii) **Electromagnet diagram:**



(iii) Soft iron core is used to make electromagnets as it gains and looses magnetism quickly.

(iv) The strength of an electromagnet can be increased by:

(a) increasing the current.

(b) increasing the number of turns in the coil.

TiP

Learn and understand the concepts of both bar magnet and solenoid and make a list of how each one differs from the other one.

Q 4. With the help of a diagram of experimental set-up, describe an activity to show that the force acting on a current carrying conductor placed in a magnetic field increases with increase in field strength. *(CBSE 2015, 20)*

Ans. Objective: To show through an activity that force acting on a current carrying conductor placed in a magnetic field increases with increase in the field strength.

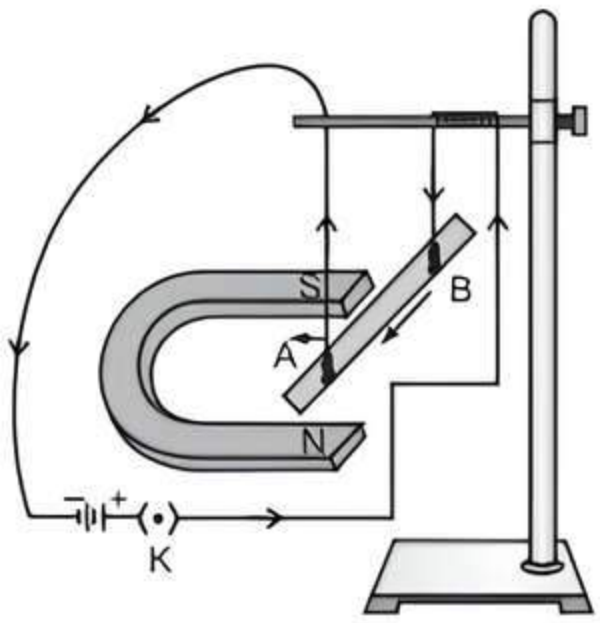
Apparatus Required: Aluminium rod, two horseshoe magnets of different intensities, a clamp stand, a cell, a key, a rod and connecting wires, etc.

Procedure:

(I) Firstly, the experimental set-up is arranged as shown in figure.

(ii) Plug the key for the given set-up. The current will flow through the rod from A and B and note the displacement of rod.

(iii) In this step, the key is unplugged and the first horseshoe magnet is removed. Now, place the second horseshoe magnet of a higher magnetic field strength in a similar manner as the first one.



(iv) Now, plug the key. The current again flows through the rod from A to B. Again observe the deflection of the rod.

(v) Now, bring both the magnets closer (to ensure greater magnetic field than that of previous case). Again observe the deflection of the rod.

Observation: Every time, the conductor deflects faster than that of previous one. It is possible only when the conductor gets more accelerated every time which requires more applied force. Thus, if the magnetic field strength is increased, the rod will exert a greater force and deflects even faster.

Conclusion: The force working on a current carrying conductor kept in a magnetic field increases with increase in the strength of field.

TiP

Students should write activity with the observation and proper labelled diagram.

Q 5. (i) Explain why there are two separate circuits one for high power rating appliances and other for low power rating appliances.

(ii) A domestic circuit has 5 A fuse. How many bulbs of rating 100 W, 220 V can be safely used in this circuit? Justify your answer.

Ans. (i) In the domestic wiring, two separate circuits are set—one for high power rating appliances namely power circuit and other for low power rating appliances called lightning circuit.

Power Circuit: The circuit drawing heavy current (15 A) from mains and used for high power rating devices such as geysers, washing machine, etc., is called power circuit.

Lightning Circuit: The circuit which draws small amount of current from the mains and is used for low power rating devices such as bulb, tubelight, fans, etc., having a current rating of 5 A, is called lightning circuit.

(ii) Given, power rating of bulb = 100 W, 220 V, $I = 5$ A, $V = 220$ V and $P = n \times 100$ W where n = Number of bulbs

Electric current flowing in the circuit

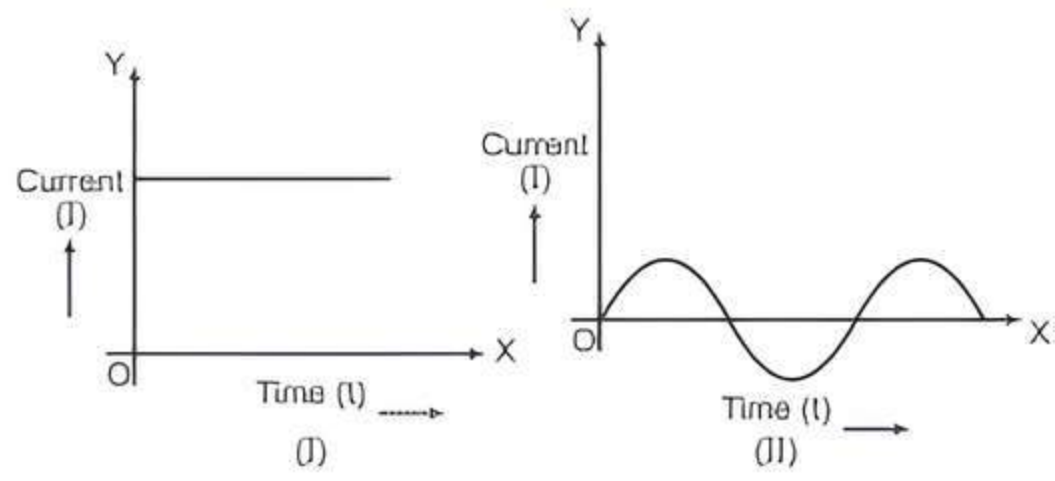
$$I = \frac{P}{V}$$

$$\Rightarrow \quad 5 = n \times \frac{100}{220}$$

$$\Rightarrow \quad n = 5 \times \frac{220}{100} = \frac{1100}{100} = 11$$

Hence, in the domestic circuit ,11 bulbs of 100 W can be used having potential difference of 220 V.

Q 6. In our daily life, we use two types of electric current whose current-time graphs are given below:



(i) Identify the types of current in each case.

(ii) Identify any one source of each type of current.

(iii) What is frequency of current used in domestic supply in India?

(iv) On the basis of graphs, write difference between the two currents.

(v) Out of two, which one is used in transmitting electric power over long distance and why?

(CBSE 2016)

Ans. (i) The types of current are: DC in case-I and AC in the case-II.

(ii) Source of DC – Cell or a battery.
Source of AC – Generator.

(iii) Frequency of AC used in domestic supply in India is 50 Hz whereas DC has zero frequency.

(iv) In case-I, current remains constant and the frequency is zero. But in case-II, current varies periodically with a frequency of 50 Hz in India.

(v) AC is used to transmit electric power over long distances without much loss of energy as compared to a DC transmission.

Chapter Test

Multiple Choice Questions

Q 1. The strength of magnetic field inside a long current carrying straight solenoid is:

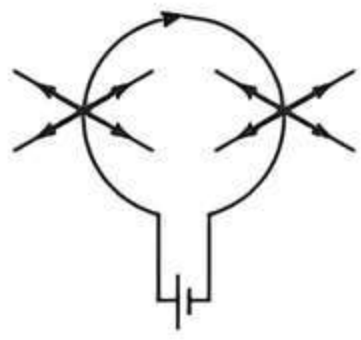
a. more at the ends than at the centre
b. minimum in the middle
c. same at all points
d. found to increase from one end to the other

Q 2. Which of the following correctly describes the magnetic field near a long straight wire?

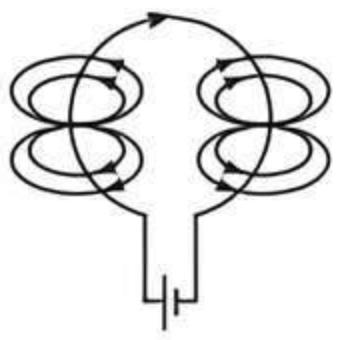
a. The field consists of straight lines perpendicular to the wire
b. The field consists of straight lines parallel to the wire
c. The field consists of radial lines originating from the wire
d. The field consists of concentric circles centred on the wire

Q 3. Which diagram shows the magnetic field lines around a current carrying circular loop?

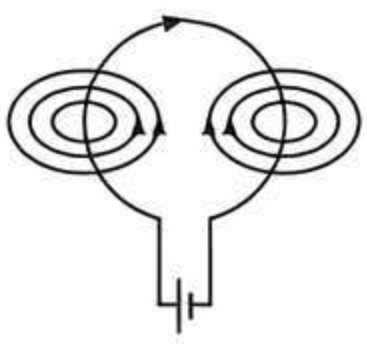
a.



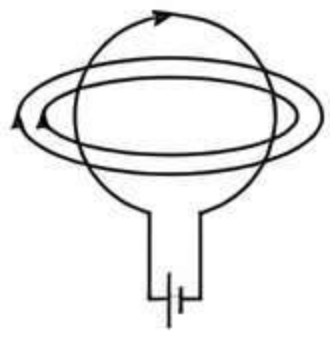
b.



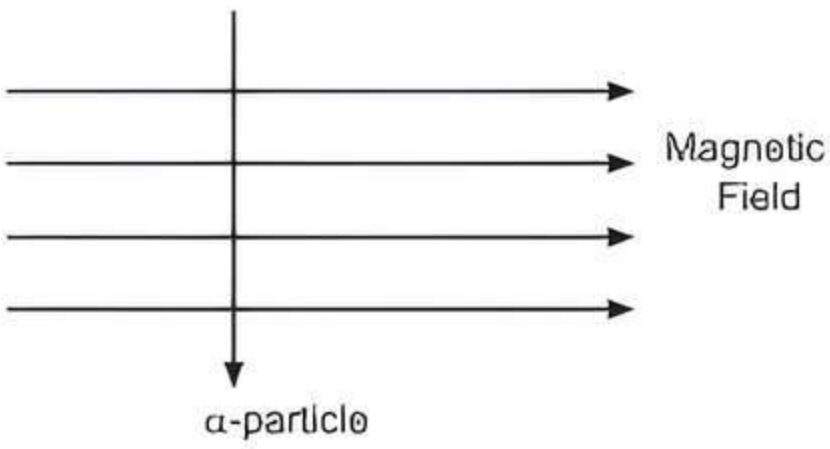
c.



d.



Q 4. An α- particle enters in a uniform magnetic field as shown. The direction of force experienced by the α- particle is:



a. towards right
b. towards left
c. into the page
d. out of the page

Assertion and Reason Type Questions

Directions (Q. Nos. 5-6): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Give answer:*

a. Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
b. Both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
c. Assertion (A) is true but Reason (R) is false.
d. Assertion (A) is false but Reason (R) is true.

Q 5. Assertion (A): The strength of the magnetic field produced at the centre of a current carrying circular coil increases on increasing the radius of the circular coil.

Reason (R): Magnetic field strength is inversely proportional to the radius of the circular coil.

Q 6. Assertion (A): In Fleming's left-hand rule, the direction of magnetic field, force and current are mutually perpendicular.

Reason (R): Fleming's left-hand rule is applied to measure the induced current.

Case Study Based Question

Q 7. Different magnetic field patterns are produced by current carrying conductors having different shapes.

The magnetic field lines around a straight conductor (straight wire) carrying current are concentric circles whose centres lie on the wire. It has been shown by experiments that the magnitude of magnetic field produced by a straight current carrying wire at a given point is: (i) directly proportional to the current passing in the wire, and (ii) inversely proportional to the distance of that point from the wire.

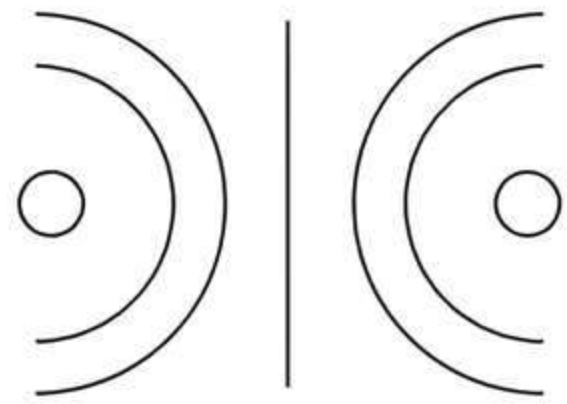
The magnetic field lines are circular near the current carrying circular loop. As we move away, the concentric circles representing magnetic field lines become bigger and at the centre, the magnetic field lines are straight.

Read the above passage carefully and give the answer of the following questions:

(i) The direction of magnetic field developed around a current carrying conductor can be easily found by the use of:

a. Fleming's left-hand rule
b. Left-hand thumb rule
c. Right-hand thumb rule
d. Fleming's right-hand rule

(ii) The diagram given below represents magnetic field caused by a current carrying conductor which is:



a. a solenoid
b. a long straight wire
c. a circular coil
d. a short straight wire

(iii) The strength of magnetic field due to a straight conductor depends on the:

a. nature of conductor
b. current passing through the wire
c. direction of current
d. All of the above

(iv) The strength of magnetic field inside a long current carrying straight solenoid is:

a. same at all points
b. minimum in the middle
c. found to increase from one end to the other
d. more at the ends than at the centre

Very Short Answer Type Questions

Q 8. What is the use of earth wire in domestic electric circuit?

Q 9. What is the direction of the magnetic field lines inside a bar magnet?

Short Answer Type-I Questions

Q 10. The given magnet is divided into three parts A, B and C.

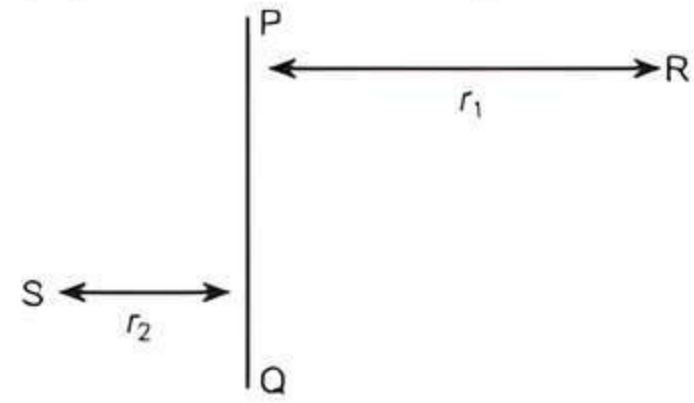
A	B	C

Name the parts where the strength of magnetic field is:

(i) maximum (ii) minimum

How will the density of magnetic field lines differ at these parts?

Q 11. *PQ* is a current carrying conductor in the plane of the paper as shown in the figure below:



(i) Find the directions of magnetic fields produced by it at points *R* and *S*?

(ii) Given $r_1 > r_2$, where will the strength of magnetic field be larger? Give reasons.

Q 12. How is the strength of magnetic field near a straight current conductor:

(i) related to the strength of current in the conductor?

(ii) is affected by changing the direction of flow of current in the conductor?

Short Answer Type-II Questions

Q 13. What is the function of an electric fuse? Name the material used for making a fuse. In a household circuit, where is fuse connected? Distinguish between overloading and short circuiting.

Q 14. What is a solenoid? Draw a diagram to show the pattern of magnetic field around a current carrying solenoid. Name the region of uniform magnetic field. *(CBSE 2023)*

Q 15. Name, state and explain with an example the rule used to determine the direction of force experienced by a current carrying conductor placed in a uniform magnetic field.

Long Answer Type Questions

Q 16. Describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors.

Q 17. What is an electromagnet? List any two uses.

(i) Draw a labelled diagram to show an electromagnet is made.

(ii) State the purpose of soft iron core used in making an electromagnet.

(iii) List two ways of increasing the strength of an electromagnet if the material of the electromagnet is fixed.