CHAPTER 12

Magnetic Effects of Electric Current

Level - 1

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (B) is correct.

Explanation: The strength of the magnetic field produced by a current-carrying solenoid depends on:

Number of turns in the solenoid (A): A higher number of turns increases the magnetic field strength because the field lines are concentrated.

Radius of the solenoid (C): A smaller radius results in a more concentrated field, slightly affecting the field strength.

Material of the core of the solenoid (D): The core material can significantly affect the field strength. A ferromagnetic core enhances the field strength due to increased permeability.

The direction of the current (B) determines the orientation (polarity) of the magnetic field but does not affect the strength of the magnetic field.

2. Option (B) is correct.

Explanation: When a current flows through a conductor, it creates a magnetic field around it. The direction of this magnetic field can be determined using the right-hand rule. When the currents in two parallel conductors are in the same direction, the magnetic fields they create attract each other. In the given scenario, the current in the rectangular loop (ABCD) and the straight conductor (XY) are in the same direction. Therefore, the magnetic field created by the loop will attract the conductor XY towards it, causing it to move towards side AB of the loop.

3. Option (C) is correct.

Explanation: A solenoid is a coil of wire. When carrying current, a solenoid produces a magnetic field similar to the field of a bar magnet. In such a field, the magnetic field lines form circles centred on the wire. The direction of the magnetic field generated by a current is determined by the "right-hand rule".

4. Option (A) is correct.

Explanation: For the given figure, the proton and electron are moving in opposite directions to each other and is perpendicular to the direction of magnetic field. Now, we know that the direction of current is taken opposite to the direction of motion of electron. So, both electron and proton have current in same direction. Therefore, the forces acting on them are given by Fleming's left-hand rule and they are pointing into the plane of the paper.

5. Option (C) is correct.

Explanation: The magnetic fields produced at the midpoint P, by the currents flowing in the same direction in the two parallel wires will be equal in magnitude but opposite in direction. Hence, the resultant magnetic field at P will be zero.

6. Option (C) is correct.

Explanation: According to Fleming's left-hand rule, the direction of the force is parallel to the directions of the magnetic field and current. Here, the stream is flowing upward and the magnetic field is to the right (opposite to the flow of electron). The direction of the force is perpendicular to the directions of the magnetic field and current, according to Fleming's left-hand rule. We are aware that the flow of current happens in the opposite path to the way electrons move. As a result, the power is applied from the paper's plane upward. The direction of force experienced by positron will be into the paper.

7. Option (C) is correct.

Explanation: Magnetic field lines enter from the south pole and exit from the north pole. A circular coil that conducts current has curved lines, a straight line running through the centre, and concentric circles at the coil's two opposite ends.

8. Option (D) is correct.

Explanation: According to Fleming's hand rule, the current flows in the direction of the alpha particle, the field points in the direction of the paper's right side, and the force is directed out of the paper by thumb.

9. Option (B) is correct.

Explanation: If we observe the direction of the magnetic field by applying right hand thumb rule, then we will find that the direction of the magnetic field is from north to south below the wire.

10. Option (C) is correct.

Explanation: A solenoid works similarly to a bar magnet. As a result, the magnetic field pattern associated with the solenoid and around the bar magnet is identical.

11. Option (D) is correct.

Explanation: The magnetic field inside a long straight current-carrying solenoid is uniform and directed along its axis. This is because the solenoid produces a nearly uniform magnetic field within its interior due to the closely spaced circular loops of current, while the field outside is negligible.

12. Option (A) is correct.

Explanation: Shape of magnetic field lines inside a solenoid is always parallel and straight and the magnetic field lines formed by a straight conductor is always concentric circles .

Assertion-Reason Questions (1 Mark)

1. Option (D) is correct.

Explanation: Assertion is false because the deflection of a compass needle is directly proportional to the strength of the magnetic field. Increasing the current increases the magnetic field, which will increase the deflection of the compass needle.

Reason is correct. The magnetic field (B) around a straight current-carrying conductor is proportional to the current (I).

2. Option (A) is correct.

Explanation: Assertion is true that magnetic field lines never intersect each other. This is because if they did intersect, it would imply that at the point of intersection, a compass needle would have to point in two different directions simultaneously, which is impossible. The reason provided explains this concept clearly and accurately stating the impossibility of compass needle pointing towards two directions at once due to the inherent nature of magnetic fields.

3. Option (A) is correct.

Explanation: Magnetic field strength is directly proportional to the number of turns of the circular coil. Hence, strength of the magnetic field increases on increasing the number of turns in it because current in each circular turn has the same direction and the magnetic field due to each turn then just adds up.

4. Option (B) is correct.

Explanation: Magnetic field lines are imaginary lines used to represent the direction of the magnetic field at different points in space. The tangent to a magnetic field line at any point gives the direction of the magnetic field at that point. The reason for magnetic field lines not intersecting each other is that the direction of the magnetic field at any point can only be a single direction, and if two field lines intersect, there will be two directions of the magnetic field at the intersection point, which is not possible. However, the reason does not directly explain why magnetic fields do not intersect each other.

5. Option (B) is correct.

Explanation: Assertion is true. A current-carrying conductor placed in a magnetic field experiences a force due to the interaction between the magnetic field and the moving charges in the conductor. Reason is also true but irrelevant to the assertion. The net charge on a conductor remains zero because the flow of current involves the movement of free electrons, but the conductor as a whole does not gain or lose charge. However, this has no direct connection to the force experienced by the conductor in a magnetic field.

6. Option (B) is correct.

Explanation: Assertion is correct. Magnetic field lines represent the direction of the magnetic field at a point. If two magnetic field lines intersect, it would imply that the magnetic field has two different directions at the same point, which is not possible.

Reason is also correct. The magnetic field (B) produced by a current-carrying straight wire is directly proportional to the current (I) through the wire. While both the assertion and the reason are true, the reason is not the explanation for the assertion. The non-intersection of magnetic field lines is a fundamental property of field lines, independent of the magnitude of the current or the strength of the magnetic field.

7. Option (B) is correct.

Explanation: Assertion is correct. The magnetic field around a straight current-carrying conductor forms concentric circles in the plane perpendicular to the conductor. This can be visualised using iron filings, which align along the magnetic field lines.

Reason is also correct. A magnetic field is a vector quantity, meaning it has both magnitude and direction. The circular arrangement of the iron filings is due to the direction of the magnetic field around the conductor.

Both assertion and reason are true but reason does not explain why iron filings arrange themselves in concentric circles.

Level - 2

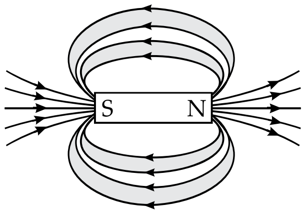
CASE BASED QUESTIONS (4 Mark)

1. (i) No, two magnetic field lines are not found to intersect each other. If two field lines intersect each other, it would mean that at the point of intersection, the compass needle would point in two directions at the same time, which is not possible.

(ii) (1) The magnetic field lines always make close loop.

(2) A tangent at a point on field shows the direction of magnetic field at that point.

(iii) (a) The space around the magnet in which compass rests in a definite direction and other magnet experiences a force is called the magnetic field.



OR

(b) (i) Outside the magnetic, the magnetic field lines always begin from the N-pole of a magnet and end on the S-pole of the magnet. Inside the magnet, however the direction of magnetic field lines is from the S-pole of the magnet to the N-pole of the magnet. Thus, the magnetic field lines are make closed curved not open.

(ii) The strength of magnetic field is determined by the closeness of field lines.

2. (i) According to Fleming's left-hand rule, the direction of force on the direction will be in the south direction.

(ii) The two conditions when magnetic field exerts no force on charge particle,

(1) On stationary electric charge.

(2) When charge particle moves parallel to the direction of magnetic field.

(iii) (a) Magnetic force on moving charge particle in magnetic is defined as,

$$F = qBv \sin\theta$$

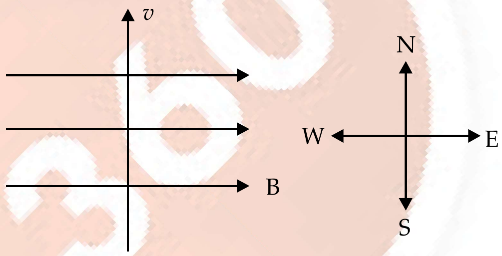
Magnitude of magnetic force,

Given: $q = 5\mu C$, $v = 5000$ m/s, B = 10 tesla, $\theta = 90°$

Now, $F = 5 \times 10^{-6} \times 10 \times 5000 \times \sin 90°$

$F = 25 \times 10^{-2}$ N

Direction of magnetic force,



According to Fleming's left-hand rule, direction of magnetic force perpendicularly downward to the paper plane.

OR

(b) Fleming's left-hand rule: According to this rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If first finger points in the direction of magnetic field and the middle finger in the direction of current, then thumb will point in the force acting on the conductor.

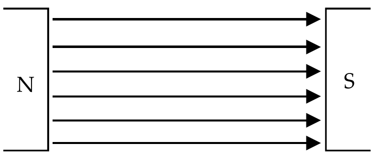
If the direction of magnetic field will reverse, the direction of force on current carrying wire will be reverse also.

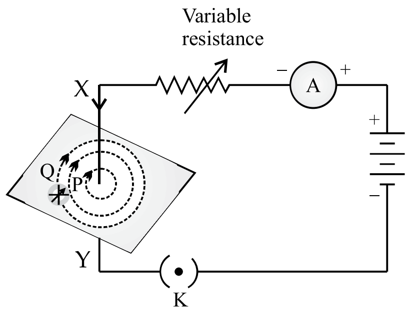
Level - 3

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

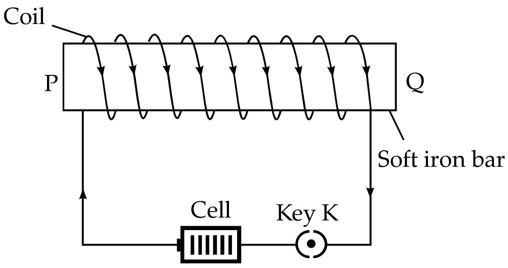
1. (i) Two magnetic field lines do not intersect each other due to the fact that the resultant force on a north pole at any point can be only in one direction. But if the two magnetic lines intersect one another, this means that resultant force on a north pole placed at the point of intersection will be along two directions, which is not possible.

(ii) Straight and parallel lines represent a homogenous magnetic field inside a specified location. These lines demonstrate that the magnetic field is constant in intensity and direction across the region.



2. 

3. A permanent magnet or current carrying solenoid is used to magnetise a piece of magnetic material.



Making a bar electromagnet

PQ is a soft iron rod whose end P behaves as south pole and end Q behaves a north pole when soft iron rod is placed in a line with magnetic field.

4. **(i)** The direction of magnetic field produced around a current-carrying conductor is given by right-hand thumb rule. If the conductor carrying current is held in the right hand in such a way that the thumb points in the direction of current, then the direction of curl of fingers gives the direction of the magnetic field.

(ii) The direction of force experienced by a straight conductor carrying current placed in a magnetic field, which is perpendicular to it is determined by Fleming's left-hand rule. Stretch the thumb and first two fingers of the left hand at right angles to each other with the first finger pointing in the direction of the field and the second finger in the direction of the current, then the thumb points in the direction of the motion.

5. **(i)** The magnetic field at P and Q is the same. Because the magnetic field lines inside the helical coil of wire which behaves like a solenoid is uniform/in the form of parallel straight lines.

(ii) **(1)** Increasing/decreasing the number of turn in the coil.

(2) Increasing/decreasing the current through the coil.

6. **(i)** The current in the loop is clockwise.

(ii) The rule used is the Right Hand Thumb rule.

The Right-Hand Thumb Rule states "If you curl the fingers of your right hand around the loop in the direction of the current, the thumb points in the direction of the magnetic field inside the loop".

7. **(i)** The Fleming's Left-Hand Rule is used to determine the direction of the force experienced by a current-carrying straight conductor placed in a magnetic field perpendicular to it.

(ii) The magnitude of the force (and hence the displacement) on the conductor depends on the angle (θ) between the current and the magnetic field.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. **(i)** Magnetic field strength is inversely proportional to the distance from the current carrying wire. Hence, when Mona moved the compass away from the current carrying wire, the magnetic effect was less on it and hence the deflection was less.

(ii) Magnetic field strength is directly proportional to the current in the wire. So, Mona could increase the current in the circuit to observe a greater deflection in the compass needle.

(iii) The battery suggests that the current is going from top of the plane to the bottom of the plane. Using the right-hand thumb rule, we can say that the magnetic field will be clockwise.

2. **(i)** Rule to determine the direction of a magnetic field produced around a current carrying straight conductor.

Rule: Right-Hand Thumb Rule

The right hand thumb rule states, "If you grasp the current-carrying conductor with your right hand such that the thumb points in the direction of the current, then the curled fingers around the conductor indicate the direction of the magnetic field".

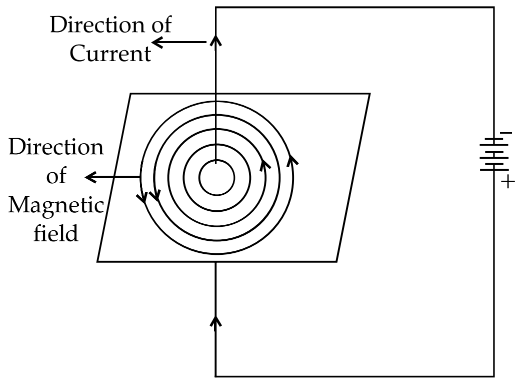
This rule helps determine the direction of the circular magnetic field lines around a straight current-carrying conductor.

(ii) Rule to determine the direction of force experienced by a current carrying straight conductor placed in a magnetic field which is perpendicular to it.

Rule: Fleming's Left-Hand Thumb Rule

According to this rule, "stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If first finger points in the direction of magnetic field and the middle finger in the direction of current, then thumb will point in the force acting on the conductor".

3.



Right-hand thumb rule: This rule states that if current-carrying wire in your right hand with you pointing in the direction of electric current flow, the direction of your curling fingers indicates the direction magnetic field's lines of force.

Yes, it is in accordance with the right-hand thumb rule.

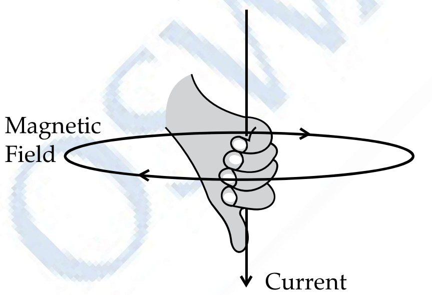
4. (i) Because a magnetic field exists around the bar magnet.

(ii) Crowding of iron filings at the ends of the magnet indicates that the strength of the magnetic field is maximum near the poles of the magnet.

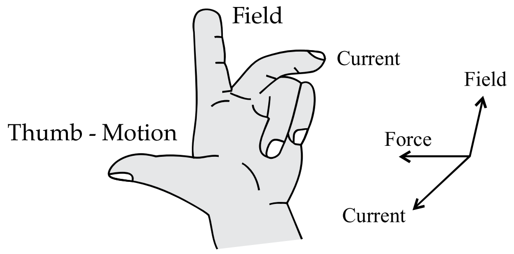
(iii) The lines represent magnetic field lines.

(iv) When a student places a cardboard horizontally in a current-carrying solenoid and sprinkles iron filings on it, the iron filings will arrange themselves in concentric circles around the solenoid. The pattern of the iron filings will show the magnetic field lines of the solenoid. The pattern will be uniform inside the solenoid and more spread out outside.

5. (i) (a) Right Hand Thumb Rule states that If you hold a current-carrying conductor in your right hand such that your thumb points in the direction of the electric current, the direction in which your fingers curling around the conductor gives the direction of the magnetic field."



(b) Fleming's Left Hand Rule states that if we arrange our thumb, forefinger and middle finger of the left-hand mutually perpendicular to each other, then the thumb points towards the direction of the force experienced by the conductor, the forefinger points towards the direction of the magnetic field and the middle finger points towards the direction of the electric current.



(ii) The direction of the force experienced by the proton is out of the plane of the paper.

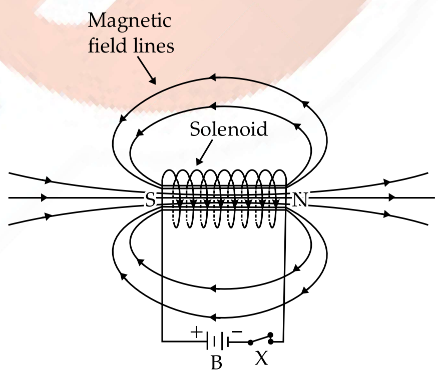
6. (i) Fleming's left-hand rule is used to find the direction of force acting on a current carrying conductor, placed in a magnetic field.

According to this rule: Stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If the forefinger points in the direction of magnetic field and the middle finger in the direction of current, then the thumb will point in the direction of motion or force acting on conductor.

(ii) (1) Force on electron is maximum in diagram (i) because here direction of motion of electron is at right angles to the magnetic field.

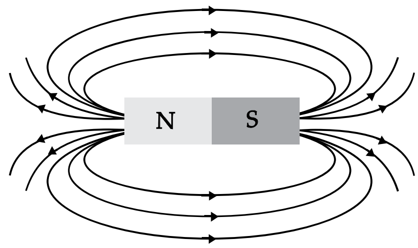
(2) Force on electron is minimum in diagram (iii) because here direction of motion of electron is along the direction of the magnetic field.

7. (i) (1)



Magnetic field lines of a current carrying solenoid

(2)



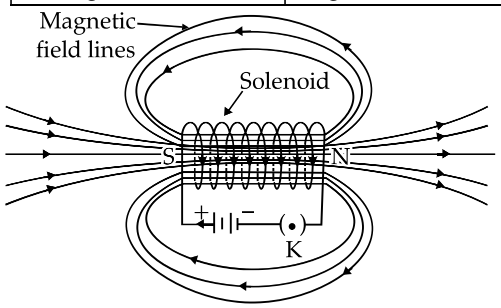
Magnetic field lines of a bar magnet

(ii)

Magnetic Field of a Solenoid	Magnetic Field lines of a Bar magnet
(1) The strength of the magnetic field can be changed by changing the current.	The strength of the magnetic field for a bar magnet cannot be changed.

(2) The direction of magnetic field can be reversed by reversing the direction of current.	The direction of magnetic field for a bar magnet cannot be changed.
(3) It is a temporary magnetic field.	It is a permanent magnetic field.

8. (i)



(ii) Magnetic field strength outside of the solenoid is minimal. The magnetic field strength at the ends of the solenoid is half that inside. Field strength is thus;

Minimum – at point B; Maximum – at point A.

9. (i) (1) Increasing the current will increase the displacement to the left.

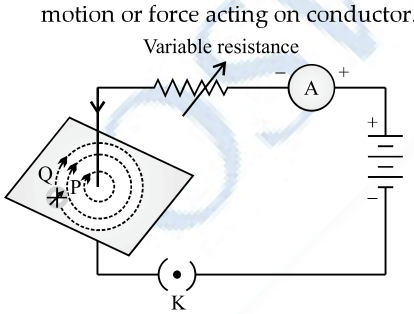
(2) Using a stronger magnet will also increase the displacement to the left.

(3) Reversing the current direction will reverse the direction of displacement and the conductor will move to the right.

(ii) Fleming's left-hand rule is used to find the direction of force acting on a current carrying conductor, placed in a magnetic field.

According to this rule, stretch the thumb, forefinger and middle finger of your left hand such that they are mutually perpendicular. If the forefinger points in the direction of magnetic field and the middle finger in the direction of current, then the thumb will point in the direction of motion or force acting on conductor.

10.



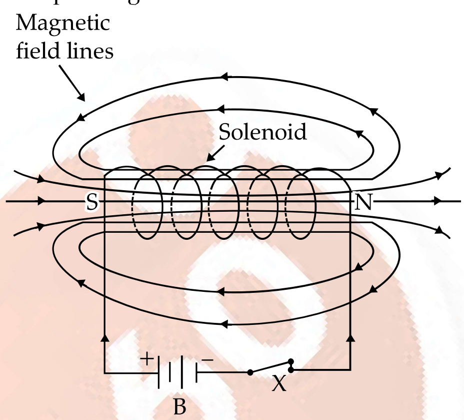
The right-hand thumb rule is used to find the direction of the magnetic fields. According to this rule, if we place our right hand thumb along the direction of the current flowing in a current carrying wire, the direction in which the fingers wrap the wire represents the direction of the magnetic field.

11. A solenoid is a coil of wire wound in the form of a cylinder, often closely packed, through which an electric current is passed. It generates a magnetic field similar to that of a bar magnet when current flows through it.

A solenoid behaves as a magnet when:

(1) An electric current is passed through it.

(2) The magnetic field lines form a pattern resembling that of a bar magnet, with a north pole and a south pole depending on the direction of the current.



12. (i)

Basis	Solenoid	Circular coil
Structure	A solenoid is a long cylindrical coil with multiple turns of wire wound closely in a helical shape.	A circular coil consists of one or a few circular loops of wire.
Magnetic field	The magnetic field inside a solenoid is strong, uniform, and resembles that of a bar magnet.	The magnetic field is strong at the centre of the coil and weakens as you move away from it.
Application	Used to produce strong, uniform magnetic fields.	Used in devices like galvanometers and speakers.

(ii) Materials Needed:

An insulated copper wire.

A cylindrical object (e.g., a plastic or cardboard tube).

A battery or power source.

An iron rod (optional, for creating an electromagnet).

Procedure:

Take the cylindrical object as the base for the solenoid.

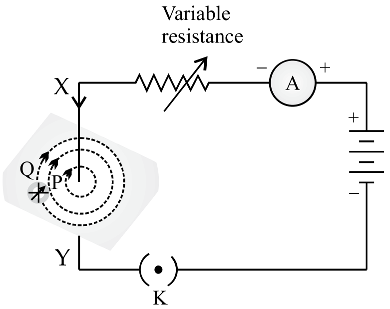
Wind the insulated copper wire tightly around the cylinder in a helical manner, making multiple turns close to each other.

Connect the two ends of the wire to the terminals of a battery or power source.

To increase the strength of the magnetic field, insert an iron rod inside the solenoid (this creates an electromagnet).

(iii) The strong magnetic field produced inside a current-carrying solenoid is used in electromagnets.

13.

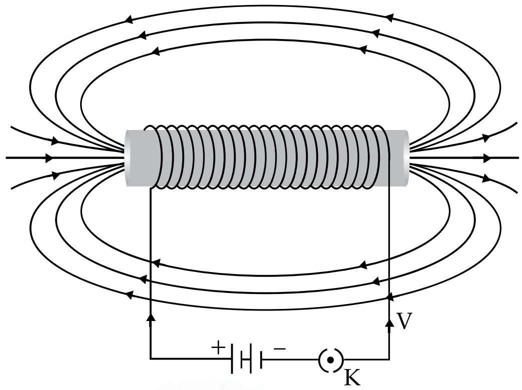


When current is passed through the conductor then concentric magnetic field lines will be produced. The strength of the magnetic field keeps on decreasing as we away from the wire.

We use the right-hand thumb rule to find the direction of the magnetic field.

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

14. (i)



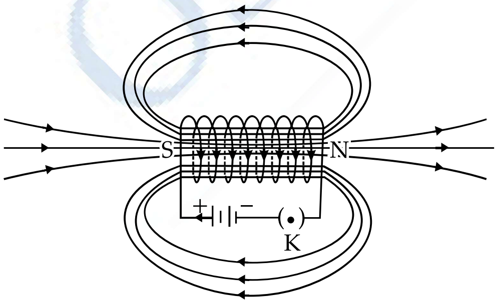
(ii) (1) Use of Properly Rated Fuses or Circuit Breakers: Ensure that the electrical circuit is equipped with fuses or circuit breakers rated appropriately for the maximum current that the circuit is designed to carry. Fuses or circuit breakers automatically disconnect the circuit when the current exceeds a safe limit, preventing overloading.

(2) Avoid Plugging Yoo Many Appliances into One Socket: Do not overload a single electrical socket by plugging in multiple high-power appliances. This can exceed the safe current rating of the socket and cause overheating, which could lead to a fire hazard. Use multi-socket extension cords with built-in protection if needed, but ensure they are rated for the load.

LONG ANSWER TYPE QUESTIONS (5 Marks)

1. A solenoid is a long coil of wire wound in the form of a helix, which carries an electric current. When a current flows through the solenoid, it produces a uniform magnetic field inside the coil and a weaker magnetic field outside it.

The magnetic field lines around a solenoid emerge from the north pole and passing through the south pole makes a continuous loop. The magnetic field lines inside the solenoid become almost straight and parallel to each other. A schematic representation has been shown below:



A solenoid can be used to magnetize a piece of soft iron by placing the iron inside the solenoid while a current flows through the solenoid. The magnetic field produced by the solenoid induces a magnetic field in the soft iron, aligning its magnetic domains. Here's how it works:

(1) Place the soft iron inside the solenoid: The solenoid produces a magnetic field when the current flows through it.

(2) Magnetic induction: The magnetic field from the solenoid causes the magnetic domains in the soft iron to align in the same direction, magnetizing the iron.

(3) Result: The piece of soft iron becomes temporarily magnetised and behaves like a magnet while the current is flowing. Once the current is turned off, the soft iron loses its magnetism quickly, as it is made of a material that does not retain magnetism for long.