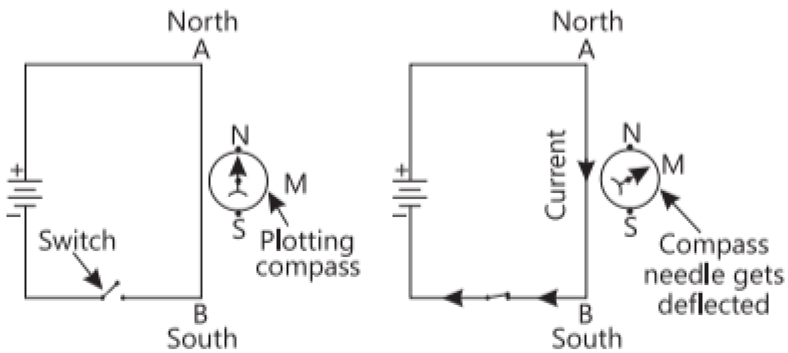
Magnetic Effects of Electric Current

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:

Q1. Oersted experiment explained................. effect of current.

a. electric field

b. magnetic field

c. Both a. and b.

d. None of these

Q2. 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

Q3. 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

Q4. 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

Q5. 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

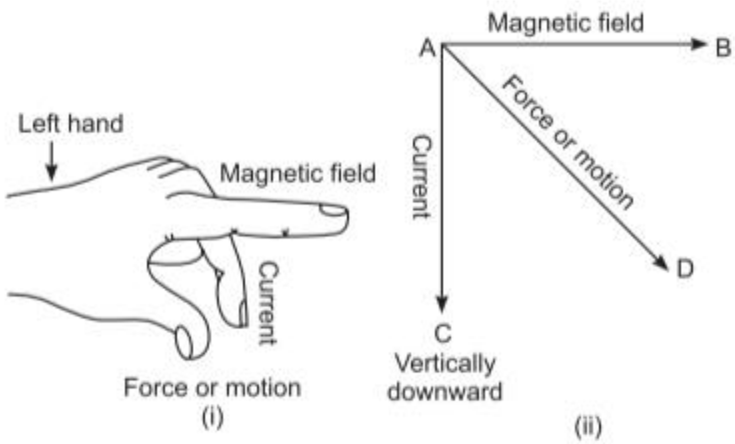
3. (c) A compass needle

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:

Q1. 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

Q2. 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

Q3. A magnetic field exerts no force on:

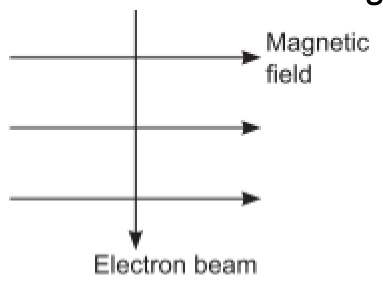
a. a stationary electric charge

b. a magnet

c. an electric charge moving perpendicular to its direction

d. an unmagnetised iron bar

Q4. 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
c. to the page
b. to the right
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.

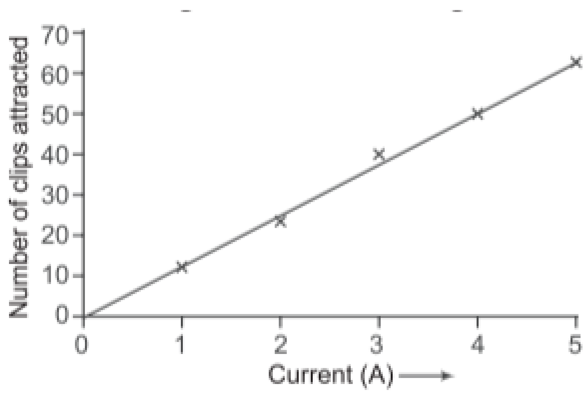
2. (d) The angle between velocity and magnetic field is zero. Therefore, magnetic force on the particle is zero.

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.

Q1. Name two factors on which the strength of a magnetic field of an electromagnet depends.

Q2. Which kind of energy change takes place in an electromagnet?

Q3. Which material is used to make electromagnets and why?

Q4. 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.

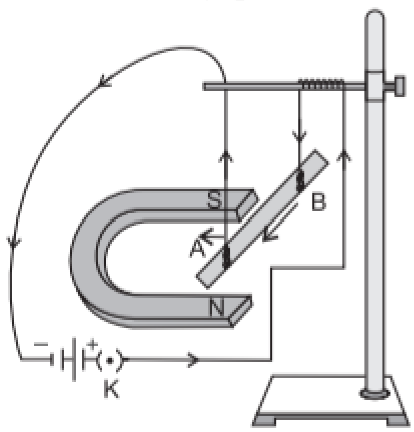
2. The energy change that takes place in an electromagnet is electrical energy to magnetic energy.

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:

Q1. Why does the rod get displaced on passing current through it?

Q2. State the rule that determines the direction of the force on the conductor AB.

Q3. (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

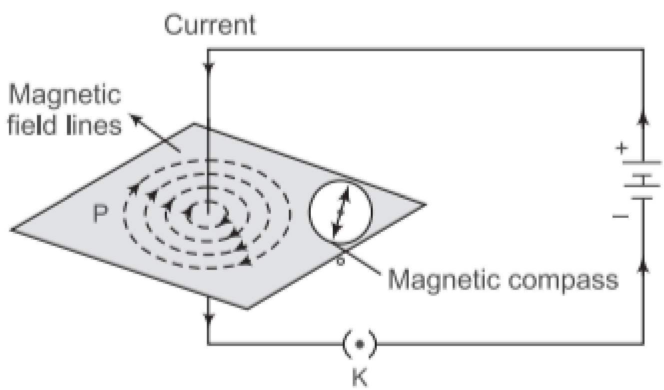
1. When a current-carrying conductor is placed in a magnetic field, a mechanical force is exerted on the conductor which makes rod displaced.

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



Solutions for Questions 5 to 9 are Given Below

Case Study 5

Read the following and answer any four questions from 1(i) to 1(v).

An insulated copper wire wound on a cylindrical cardboard tube such that its length is greater than its diameter is called a solenoid. When an electric current is passed through the solenoid, it produces a magnetic field around it. The magnetic field produced by a current-carrying solenoid is similar to the magnetic field produced by a bar magnet. The field lines inside the solenoid are in the form of parallel straight lines. The strong magnetic field produced inside a current-carrying solenoid can be used to magnetise a piece of magnetic material like soft iron, when placed inside the solenoid. The strength of magnetic field produced by a current carrying solenoid is directly proportional to the number of turns and strength of current in the solenoid.

(i) 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.

(ii) The north-south polarities of an electromagnet can be found easily by using

(a) Fleming's right-hand rule (b) Fleming's left-hand rule

(c) Clock face rule (d) Left-hand thumb rule.

(iii) For a current in a long straight solenoid N-and S-poles are created at the two ends. Among the following statements, the incorrect statement is

(a) The field lines inside the solenoid are in the form of straight lines which indicates that the magnetic field is the same at all points inside the solenoid.

(b) The strong magnetic field produced inside the solenoid can be used to magnetise a piece of magnetic material like soft iron, when placed inside the coil.

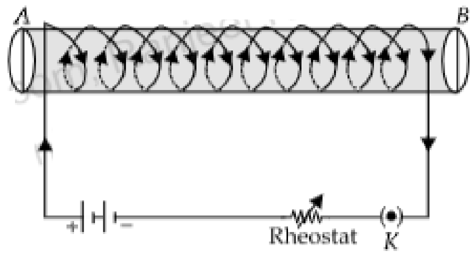
(c) The pattern of the magnetic field associated with the solenoid is different from the pattern of the magnetic field around a bar magnet.

(d) The N- and S-poles exchange position when the direction of current through the solenoid is reversed.

(iv) A long solenoid carrying a current produces a magnetic field B along its axis. If the current is double and the number of turns per cm is halved, then new value of magnetic field is

(a) B (b) $2B$ (c) $4B$ (d) $B/2$

(v) A soft iron bar is enclosed by a coil of insulated copper wire as shown in figure. When the plug of the key is closed, the face B of the iron bar marked as



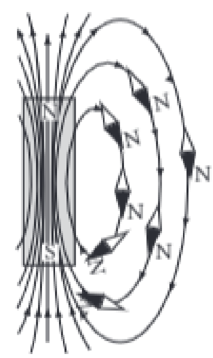
(a) N–pole (b) S–pole

(c) N–pole if current is large (d) S–pole if current is small

Case Study 6

Read the following and answer any four questions from 2(i) to 2(v).

A magnetic field is described by drawing the magnetic field lines. When a small north magnetic pole is placed in the magnetic field created by a magnet, it will experience a force. And if the north pole is free, it will move under the influence of magnetic field. The path traced by a north magnetic pole free to move under the influence of a magnetic field is called a magnetic field line. Since the direction of magnetic field line is the direction of force on a north pole, so 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 closed curves. When a small compass is moved along a magnetic field line, the compass needle always sets itself along the line tangential to it. So, a line drawn from the south pole of the compass needle to its north pole indicates the direction of the magnetic field at that point.



(i) The magnetic field lines

(a) intersect at right angle to one another

(b) intersect at an angle of 45° to each other

(c) do not cross one another

(d) cross at an angle of 60° to one another.

(ii) A strong bar magnet is placed vertically above a horizontal wooden board. The magnetic lines of force will be

(a) only in horizontal plane around the magnet

(b) only in vertical plane around the magnet

(c) in horizontal as well as in vertical planes around the magnet

(d) in all the planes around the magnet.

(iii) Magnetic field lines can be used to determine

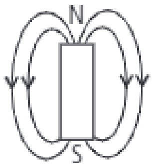
(a) the shape of the magnetic field

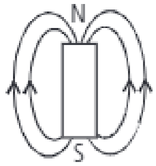
(b) only the direction of the magnetic field

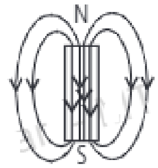
(c) only the relative strength of the magnetic field

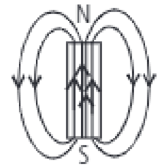
(d) both the direction and the relative strength of the magnetic field.

(iv) The magnetic field lines due to a bar magnet are correctly shown in figure

(a) 

(b) 

(c) 

(d) 

(v) Which of the following is not true about magnetic field lines?

(a) Magnetic field lines are the closed and continuous curve.

(b) No two field lines can cross each other.

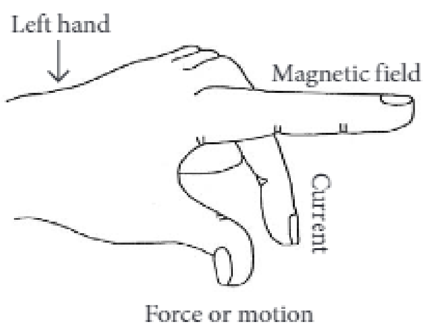
(c) Crowdness of field lines represents the strength of magnetic field.

(d) The direction of field lines is from the north pole to the south pole inside a bar magnet.

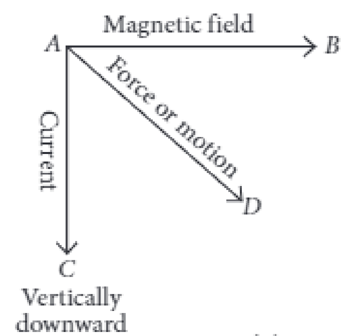
Case Study 7

Read the following and answer any four questions from 3(i) to 3(v).

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.



(*i*)



(*ii*)

(i) 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.

(ii) 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.

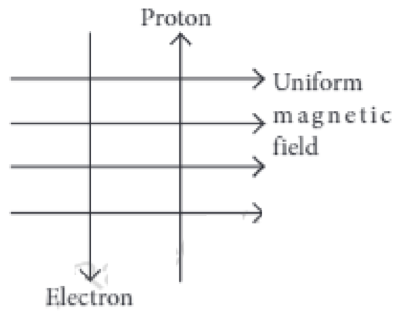
(iii) A magnetic field exerts no force on

(a) a stationary electric charge (b) a magnet

(c) an electric charge moving perpendicular to its direction

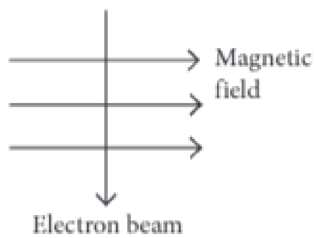
(d) an unmagnetised iron bar.

(iv) A uniform magnetic field exists in the plane of paper pointing from left to right as shown in figure. In the field an electron and a proton move as shown. The electron and the proton experience



(a) forces both pointing into the plane of paper
(b) forces both pointing out of the plane of paper
(c) forces pointing into the plane of paper and out of the plane of paper, respectively
(d) force pointing opposite and along the direction of the uniform magnetic field respectively.

(v) An electron beam enters a magnetic field at right angles to it as shown in the figure. The direction of force acting on the electron beam will be

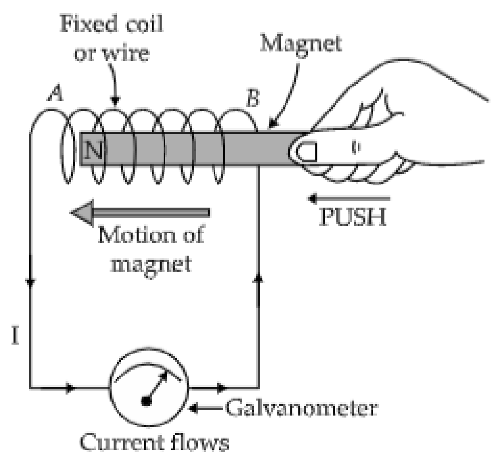


(a) to the left (b) to the right (c) into the page (d) out of the page.

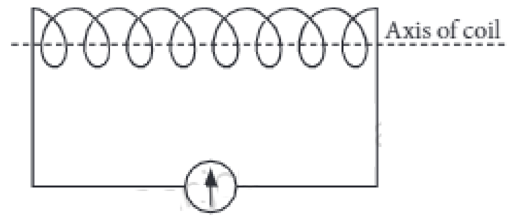
Case Study 8

Read the following and answer any four questions from 4(i) to 4(v).

A current carrying wire produces magnetic field around it. The phenomena in which an electromotive force and current (if the conductor is in the form of a closed circuit) is induced by changing magnetic field (or by passing magnetic field lines) through it is called electromagnetic induction. The emf so developed is called induced emf and current made to flow is called induced current. The cause of induced emf carried out by Faraday and Henry. It can be concluded that the induced current flows in a conductor as long as the magnetic lines of force change within the conductor. In case of relative motion *i.e.*, motion of coil w.r.t to magnet or vice versa, the direction of the current flowing in the conductor is determined by the direction of the relative motion of the conductor with respect to the magnetic field. The induced emf or current is directly proportional to the rate of change in magnetic field.

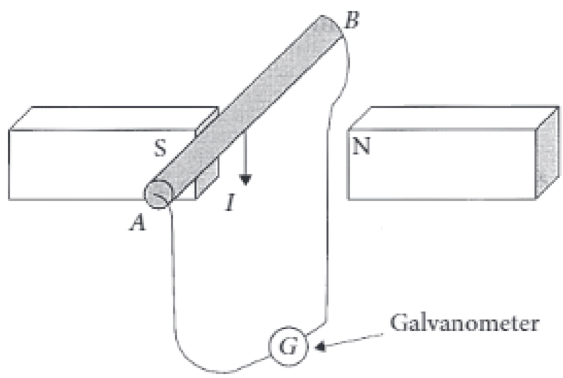


(i) A student connects a coil of wire with a sensitive galvanometer as shown in figure. He will observe the deflection in the galvanometer if bar magnet is



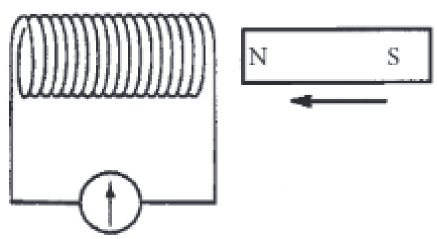
(a) placed near one of the faces of the coil and parallel to the axis of the coil
(b) placed near one of the faces of the coil and perpendicular to the axis of the coil
(c) placed inside the coil
(d) moved towards or away from the coil parallel to the axis of the coil.

(ii) A conducting rod *AB* moves across two magnets as shown in figure and the needle in the galvanometer deflects momentarily. What is the name of this physical phenomenon?



(a) Electromagnetism
(b) Induced magnetism
(c) Electromagnetic induction
(d) Static induction

(iii) A bar magnet is pushed steadily into a long solenoid connected to a sensitive meter.



Which of the following would affect the magnitude of the deflection of the meter?
(a) How fast the magnet is pushed into the coil.
(b) The direction in which the coil is wound.
(c) The end of the solenoid the magnet enters.
(d) The pole of the magnet enters the coil first.

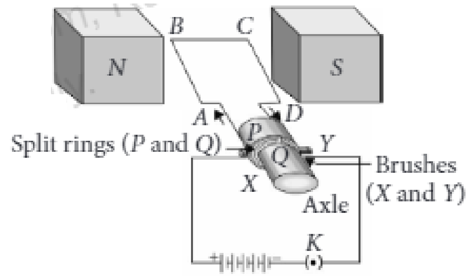
(iv) What is the condition of an electromagnetic induction?
(a) There must be a relative motion between galvanometer and coil of wire.
(b) There must be a relative motion between galvanometer and a magnet.
(c) There must be a relative motion between galvanometer and electric motor.
(d) There must be a relative motion between the coil of wire and a magnet.

(v) An induced emf is produced when a magnet is plunged into a coil. The magnitude of induced emf does not depend on
(a) the number of turns in the coil
(b) the speed with which the magnet is moved
(c) the strength of the magnet
(d) the resistivity of the material of the coil.

Case Study 9

Read the following and answer any four questions from 5(i) to 5(v).

An electric motor is a rotating device that converts electrical energy into mechanical energy. Electric motor is used as an important component in electric fans, refrigerators, mixers, washing machines, computers, MP3 players, etc.



An electric motor consists of a rectangular coil *ABCD* of insulated copper wire. The coil is placed between the two poles of a magnetic field such that the arm *AB* and *CD* are perpendicular to the direction of the magnetic field. The ends of the coil are connected to the two halves *P* and *Q* of a split ring. The inner sides of these halves are insulated and attached to an axle. The external conducting edges of *P* and *Q* touch two conducting stationary brushes *X* and *Y*, respectively, as shown in the figure.

Commercial motors use an electromagnet in place of a permanent magnet, a large number of turns of conducting wire in the current carrying coil and a soft iron core on which the coil is wound.

(i) Choose incorrect statement from the following regarding split rings.
- (a) Split rings are used to reverse the direction of current in coil.
- (b) Split rings are also known as commutator.
- (c) Split ring is a discontinuous or a broken ring.
- (d) Both (a) and (b)

(ii) Which of the following has no effect on the size of the turning effect on the coil of an electric motor?
- (a) The amount of the current in the coil.
- (b) The direction of the current in the coil.
- (c) The number of turns in the coil.
- (d) The strength of the magnetic field.

(iii) When current is switched ON, an electric fan converts
- (a) mechanical energy to chemical energy
- (b) electrical energy to mechanical energy
- (c) chemical energy to mechanical energy
- (d) mechanical energy to electrical energy.

(iv) In an electric motor, device that makes contact with the rotating rings and through them to supply current to coil is
- (a) axle
- (b) brushes
- (c) coil
- (d) split rings.

(v) In an electric motor, the direction of current in the coil changes once in each
- (a) two rotations
- (b) one rotation
- (c) half rotation
- (d) one-fourth rotation.

5. **(c):** Magnetic field inside infinite solenoid is uniform. Hence it is same at all points.

(ii) **(c)**

(iii) **(c):** The pattern of the magnetic field associated with solenoid is same as the pattern of the magnetic field around a bar magnet.

(iv) **(a):** For a long solenoid, magnetic field $B \propto In$; where I is the flowing current and n is number of turns per unit length in the solenoid. Therefore, in the given case magnetic field will remain unchanged.

(v) **(a)**

6. **(i)** **(c):** No two magnetic field lines are found to cross each other. If two field lines crossed 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) **(d):** The magnetic field and hence the magnetic line of force exist in all the planes all around the magnet.

(iii) **(d):** The relative strength of the magnetic field is shown by the degree of closeness of the field lines and the direction of the magnetic field is obtained by tangent to the field lines at the point of intersect.

(iv) **(d):** The magnetic field lines due to a bar magnet are closed continuous curves directed from N to S outside the magnet and directed from S to N inside the magnet. Hence option (d) is correct.

(v) **(d):** Inside a bar magnet, the direction of field lines is from south pole to north pole.

7. **(i)** **(d):** Fleming's left hand rule is used to determine the direction of force on electron *i.e.*, in south direction.

(ii) **(d):** The angle between velocity and magnetic field is zero. Therefore, magnetic force on the particle is zero.

(iii) **(a)**

(iv) **(a):** As the direction of current is taken opposite to the direction of motion of electrons, therefore, current from the motion of electron and proton is in the same direction, *i.e.*, from bottom to top. Now, according to Fleming's left hand rule, the electron and the proton experience forces both pointing into the plane of paper.

(v) **(c)**

8. **(i)** **(d):** The deflection in galvanometer can be seen if bar magnet moved towards or away from coil parallel to the axis of the coil.

(ii) **(c):** If the needle of the galvanometer deflects it means there is change in magnetic field and current is induced.

(iii) **(a):** By Faraday's law of electromagnetic induction, the e.m.f. induced in a conductor is proportional to the rate of change of magnetic lines of force linking the circuit. Hence, by pushing in the magnet faster, the rate of change of magnetic lines will increase. This results in a larger induced e.m.f. and hence, larger deflection of the meter.

(iv) **(d)**

(v) **(d):** Resistivity of coil will determine the resistance of the coil and induced current through it, as induced current $= \dfrac{\text{emf}}{\text{resistance}}$

9. **(i)** **(d)**

(ii) **(b):** The direction of the current has no effect on the size of the turning effect on the coil.

(iii) **(b):** Electric fan works on the principle of electric motor. It converts electrical energy to mechanical energy.

(iv) **(b)** **(v)** **(c)**