Magnetic Effects Of Electric Current

Check Point 01

Q. 1. What is the SI unit of magnetic field?

Answer: The SI unit of magnetic field is Tesla denoted by T.

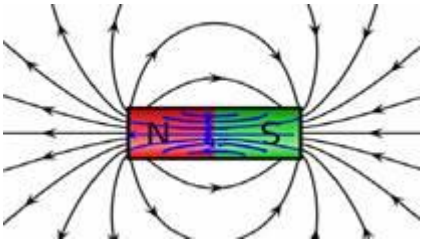
1 T is defined as the magnetic field in which particle of charge 1 Coulomb moving perpendicularly to a magnetic field at a speed of 1 m/s experiences the force of 1N.

Q. 2. What is the direction of magnetic field inside a bar magnet?

Answer: The Magnetic field lines always begin from the North 'N' pole of the magnet and ends on south 'S' pole of the magnet.

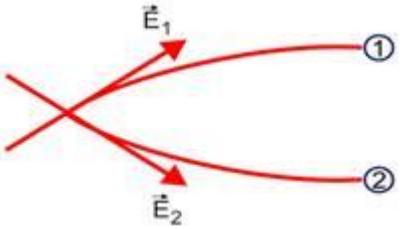
However inside the magnet the direction of magnetic field lines is from 'S' pole to 'N' pole.

The figure below illustrates the magnetic field lines direction inside the bar magnet.



Q. 3. Why can't two field lines intersect each other?

Answer: The two magnetic field lines never intersect each other because if they intersect than two tangents can be drawn from the point of intersection of the field lines which will give the two directions of the field from the same point (shown in figure below) which is impossible because the resultant force on a pole (north/south) at any point can only be in one direction. Hence the field lines never intersect.



Q. 4. How can we predict about the strength of a magnetic field in a space?

Answer: Following are the ways by which we can determine the magnetic field in a space.

1. Magnetic field can be written in terms of vector potential an by determining the potential we can find the strength.

2. By using the magnetometer we can measure the strength of the magnetic field. Figure below shows the magnetometer.

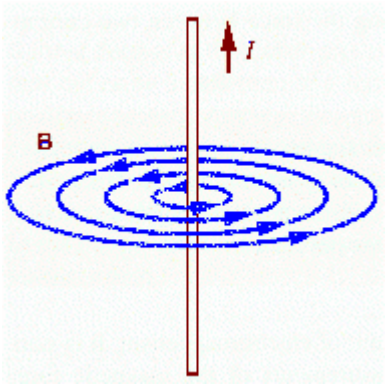
Q. 5. Where is the magnetic field due to a straight current wire

(i) Stronger
(ii) Weaker?

Answer: (i) Stronger = the magnetic field lines are stronger in the region around the wire and it decreases with the increase in the distance from the wire.

(ii) Weaker = the magnetic field lines are weaker in the region far away from the wire because as the distance from the wire increases the magnetic field intensity decreases.

Figure below shows the field lines due to wire.



Check Point 02

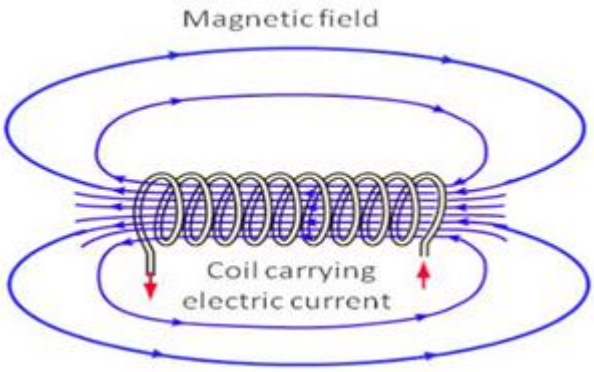
Q. 1. What happens to the strength of the magnetic field if the number of turns is increased?

Answer: The magnetic field is directly proportional to the number of turns in the magnet. Therefore on increasing the number of turns the magnetic field will increase because, with addition of each turn there will be an increase in number of charge carriers that contribute to the field at a point.

Q. 2. What is the nature of magnetic field inside a solenid?

Answer: When current is passed through a solenoid, the magnetic fields act almost like that of a bar magnet. One end acts as the magnetic north pole, and the other end acts as the magnetic South Pole.

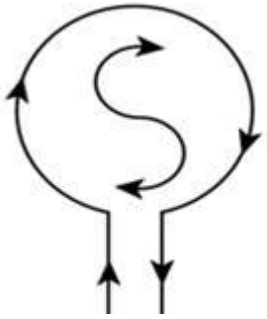
The magnetic curves inside the solenoid are in parallel straight lines, which indicate that the magnetic field is same at all points inside the solenoid. However, the field lines outside the solenoid travels from one pole to the other. Figure below shows the magnetic field lines inside the solenoid.



Q. 3. A circular loop carrying a current is placed on a horizontal surface (current is in the clockwise direction). What is the direction of its magnetic field at the centre? What is the direction of the magnetic field at a point outside the surface of the loop?

Answer: The direction of the current in the circular current carrying coil is given by the Thumb rule.

Direction of magnetic field at centre for the loop carrying current in clockwise direction is perpendicular to the plane and is inward (going into the plane) which is south pole shown in the figure below.



For the point outside the surface of the loop the direction is outwards (going outside of the plane).

Q. 4. What is difference in the pattern of magnetic field due to a circular loop and inside a solenoid?

Answer:

Circular Loop	Solenoid
1. Induced North Pole and South Pole are close to each other.	Induced north pole and south pole are some distance apart from each other due to many turns of wire.
2. Magnetic field is present inside circular loop.	No magnetic field inside because it gets cancelled by each circular loop

Q. 5. What is the principle of an electromagnet?

Answer: An electromagnet is a device used to generate a magnetic field with the help of an electric current.

Under the influence of electric current, all atoms are reoriented to start pointing in the same direction. All these individual magnetic fields together create a strong magnetic field. As the current flow increases, this degree of reorientation also increases, resulting in a stronger magnetic field.

Once all the particles are reoriented perfectly in the same direction, increasing current flow will not affect the magnetic field produced. At this point, the magnet is said to be saturated.

Check Point 03

Q. 1. When is the force on a current carrying wire.

(i) Maximum
(ii) Minimum

Answer: (i) Maximum: When the direction of current is perpendicular to the direction of the magnetic field the force on wire is maximum.

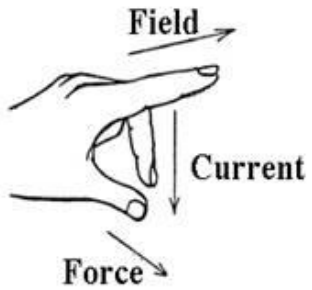
(ii) Minimum: When the direction of current is parallel to the direction of the magnetic field the force on wire is minimum.

Q. 2. Name the rule that gives the direction of force on a current carrying conductor placed perpendicular to the magnetic field.

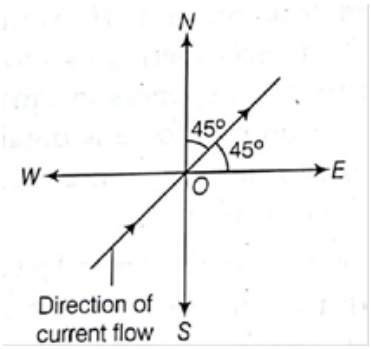
Answer: Fleming's Left hand rule gives the direction of force on a current carrying conductor placed perpendicular to the magnetic field.

Fleming's Left hand rule: According to this rule, stretch the thumb, fore-finger and middle finger of left hand such that they are mutually perpendicular. If the middle finger points in the direction of the magnetic field, the fore-finger points in the direction of flow of current, then the thumb points in the direction of motion i.e., force acting on the conductor.

Figure below illustrates it.



Q. 3. The direction of magnetic field at a place is coming out of the paper. A wire whose direction of current flow is as shown in the figure is placed there. In which direction is the force due to the magnetic field experienced by the wire?



Answer: By the right hand rule the thumb pointing in the direction of the current and the forefingers pointing in the direction of the magnetic field, than perpendicular to the palm is the direction of the force on the conductor. Therefore the direction of the force on the conductor is south west.

Q. 4. What is the cause of magnetic field inside a human body?

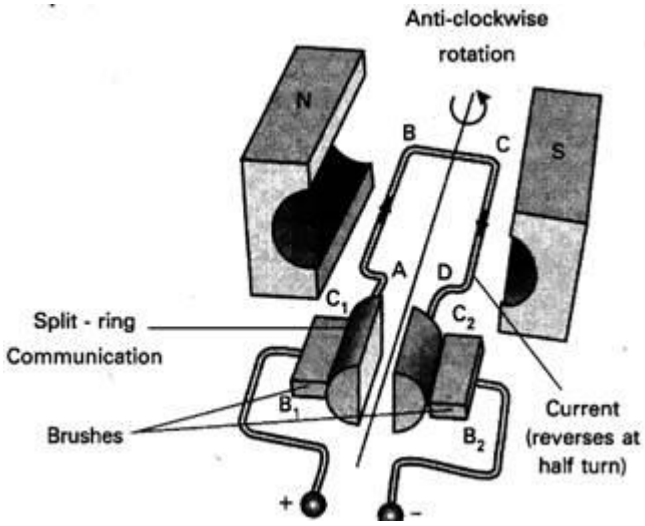
Answer: The human body magnetism comes from two sources one is magnetism from earth and other is the metabolism within the cells in the body.

In human body small electric current travel along the nerve cells due to ions, same way as electricity flows through the wire. This current produces very weak magnetic field in the human body. **Heart** and **Brain** are the two main organs in the human body where this field is significant.

Q. 5. What is an electric motor?

Answer: Electric motor is the device in which electrical energy is converted into the mechanical energy.

It works on the principle that when a rectangular coil is placed in a magnetic field and current is passed through it. A force acts on the coil which rotates it continuously. Figure below shows the electric motor



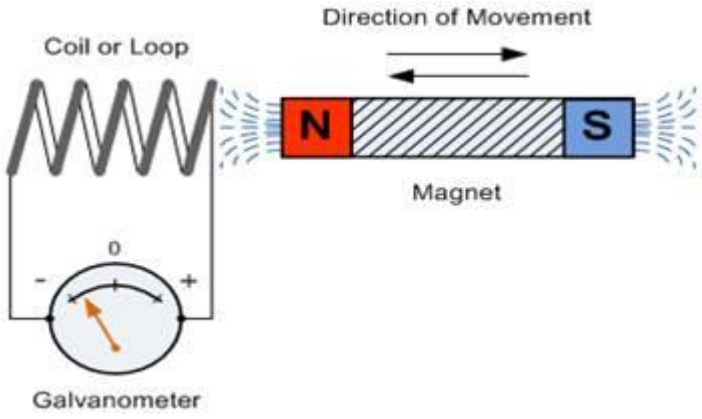
Check Point 04

Q. 1. What is electromagnetic induction?

Answer: Electromagnetic Induction is a current produced because of voltage production (electromotive force) due to a changing magnetic field. This either happens

when a conductor is placed in a moving magnetic field (when using AC power source) or when a conductor is constantly moving in a stationary magnetic field.

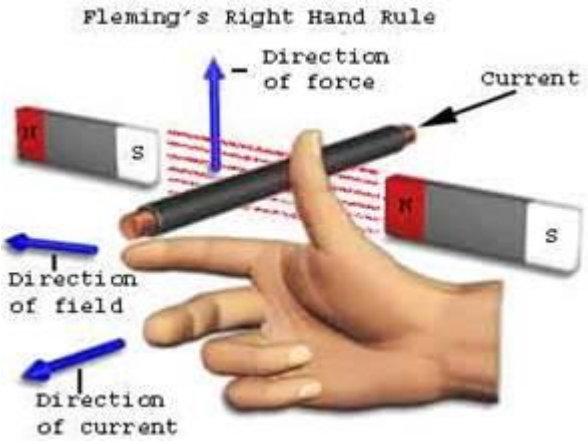
This phenomenon was discovered by Michael Faraday. Figure below shows the setup for electromagnetic induction.



Q. 2. Where is Fleming's right hand rule used?

Answer: It can be used to determine the direction of current in a generator's windings. It can also be used to show the direction of induced current when a conductor attached to a circuit moves in a magnetic field.

Fleming right hand rule is mainly applicable for the electric generator. Figure below shows how to determine the direction of current using Fleming right hand rule.



Q. 3. Differentiate between the time varying and constant currents.

Answer:

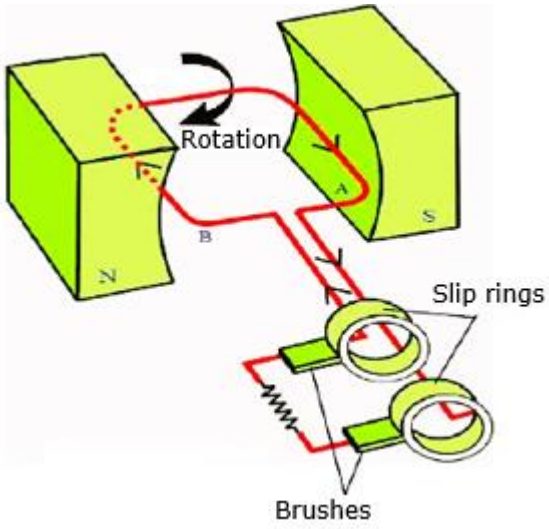
Time Varying current	Constant current
1. It is the current of magnitude varying with time	It is the current of constant magnitude.
2. It reverses its direction while flowing in a circuit.	It flows in one direction in the circuit.
3. The frequency of this current is 50Hz or 60Hz depending upon the country	The frequency of constant current is zero.
4. Safe to transfer over longer city distances and can provide more power	Voltage of constant current cannot travel very far until it begins to lose energy.

Q. 4. What is an electric generator?

Answer: Electric generator is the device which converts the mechanical energy into the electrical energy.

It works on the Faraday's law of the Electromagnetic Induction which says that whenever a conductor is placed in a varying magnetic field, EMF is induced and this induced EMF is equal to the rate of change of flux.

Electric generators are of two types A.C generator and D.C generator. Figure below shows the A.C generator.



Q. 5. Write down the differences between AC and DC generators.

Answer:

AC Generators	DC Generators
1. AC generator is a mechanical device which converts mechanical energy into AC electrical power.	DC generator is a mechanical device which converts mechanical energy into DC electrical power.
2. In an AC generator, the electrical current reverses direction periodically.	In a DC generator, the electrical current flows only in one direction.
3. AC generator does not have commutators.	DC generators have commutators to make the current flow in one direction only.
4. AC generators have slip-rings.	DC generators have split-ring commutators.

Check Point 05

Q. 1. At what potential and frequency are the domestic electric circuits operated?

Answer: In our country the potential difference is **220 V** and the frequency is **50 Hz.** It is different for the different countries. And the potential difference is between the live wire and the neutral wire.

Q. 2. Usually, three insulated wires of different colours are used in an electrical appliance. Identify the three colours.

Answer: Electrical wires follow standard color coding that helps classify each wire function in the circuit. In India wires are RGB mode i.e. Red- Green- Black. Each of these RGB wire have different functions.

1. RED = Red wire signifies the phase in electric circuit. It is the live wire which cannot be connected to another red wire or black wire.

2. BLACK = Black wires signifies neutral wire in electric circuit. The neutral wire is connected to neutral bus bar inside an electric panel.

3. GREEN = Green wire stands for grounding/ Earthing in electric circuit. A green wire should be on can be connected to green wire only (no other wire).

Q. 3. Why should a fuse wire of defined rating not be replaced by one with a larger rating?

Answer: Fuse is used for protecting appliances due to short-circuiting or overloading. The fuse is rated for a certain maximum current and blows off when a current more than the rated value flows through it.

If a fuse is replaced by one with larger ratings, the appliances may get damaged while the protecting fuse does not burn off. This practice of using fuse of improper rating should always be avoided.

Q. 4. What does it mean when we say that a circuit is short circuited?

Answer: A short circuit is an electrical circuit that allows a current to travel along an unintended path with no or a very low resistance. This results in an excessive amount of current flowing into the circuit

A common type of short circuit occurs when the positive and negative terminals of a battery are connected with a low-resistance conductor, like a wire. With a low resistance in the connection, a high current will flow, causing the delivery of a large amount of energy in a short period of time

Q. 5. What is overloading of an electric circuit?

Answer: The current in a circuit depends on the rating of the appliances connected to it. The choice of wires depends upon the maximum current estimated to pass through them. If the total power rating of the appliances exceeds this permitted limit, they tend to draw a large current. This is known as overloading due to excessive heating takes place.

Overloading occurs when too many appliances are connected in a single socket or live and neutral wires come in contact with each other.

Chapter Exercise

Q. 1. What name is given to the device which automatically cut-off the electrical supply during short circuiting in household wiring?

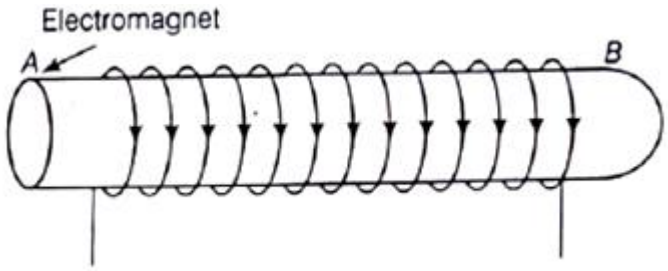
Answer: A fuse is an electrical safety device that is used to cut electrical supply during short circuit. It is a metal wire or strip that melts when too much current flows through it, thereby interrupting the current.

Figure below shows the fuse.

Q. 2. In which wire in an AC housing circuit, is the switch introduced to operate the light?

Answer: In order to prevent us from getting electric shock we have to connect all wires to the earth wires, and lights operate in live wire. Also we have to connect neutral wire to complete the circuit.

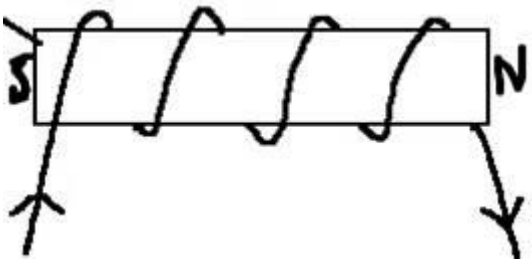
Q. 3. The diagram shows a coil of wire wound on a soft iron core forming an electromagnet. A current is passed through the coil in the direction indicated by the arrows. Mark the N and S-poles produced in the iron core.



Answer: By using the clock face rule which states that "When an observer, looking at the face of the coil, finds the current to be flowing in the anti-clockwise direction, then the face of the coil will behave like the North Pole. While if the current is in the clockwise direction, the face of the coil will behave like South Pole.

South Pole: A

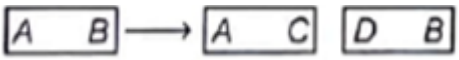
North Pole: B



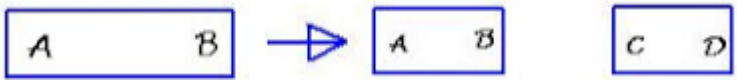
Q. 4. Why is an alternating current considered to be advantageous over direct current for long range transmission of electric energy.

Answer: Alternating current can be transmitted over the long distances without the loss of energy. Also alternating voltage can be stepped up and stepped down using transformer.

Q. 5. A magnet AB is broken into two pieces. Point out the polarity of A,B,C and D.



Answer: When the magnet AB is broken into pieces as shown in the figure below.

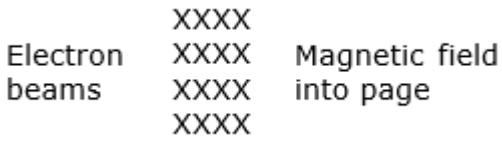


Polarity of A and C is north

Polarity of B and D is south

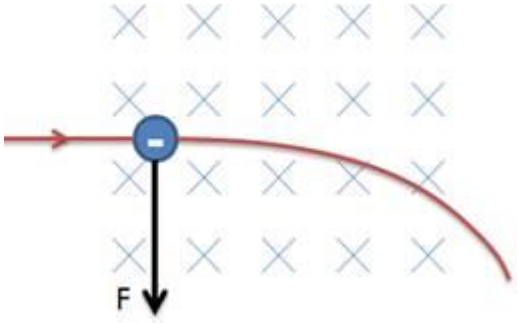
Because single poles of magnet do not exist when the magnet is broken the two poles (north and south) are created immediately.

Q. 6. The diagram shows a beam of electrons about to enter a magnetic field. The direction of the field is into the page. What will be the direction of the deflection, if any beam passes through the field?

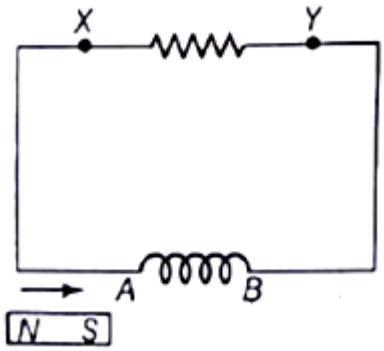


Answer: The direction of current is from left to right as the electron beam enters from left to right and the magnetic field is into the page.

According to the Fleming's left hand rule the force is perpendicular to the flow of current and is in its left side. So electron beam deflects towards bottom of the page. As shown in the figure below.

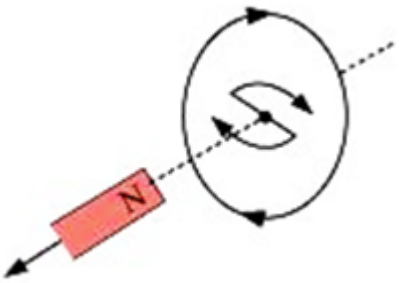


Q. 7. A small valued resistance XY is connected across the ends of a coil. Predict the direction of induced current in the resistance XY when.

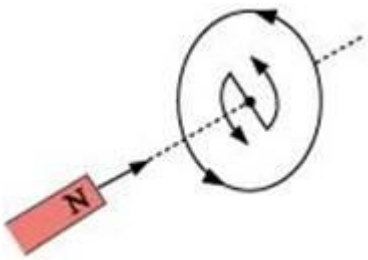


(i) South pole of a magnet moves towards end A of the coil.
(ii) South pole of a magnet moves away from end A of the coil.

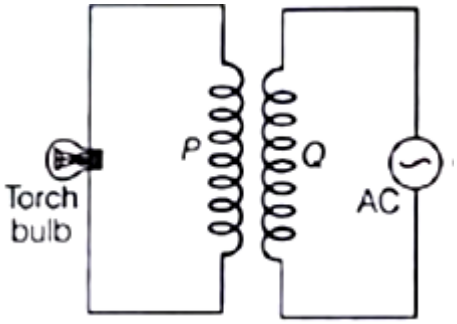
Answer: (i) According to the Lenz's Law induced emf will oppose the source of the charge, thus to oppose the approaching South Pole magnetic South Pole will be developed at the end of the magnet. Thus the current will flow in the clockwise direction as shown in the figure below.



(ii) According to the Lenz's Law induced emf will oppose the source of the charge, thus to oppose the going away South Pole magnetic North Pole will be developed at the end of the magnet so that the south pole of the magnet do not go away. Thus the current will flow in the anticlockwise direction as shown in the figure below.



Q. 8. A coil P is connected to a torch bulb and placed to another coil Q as shown in figure below:



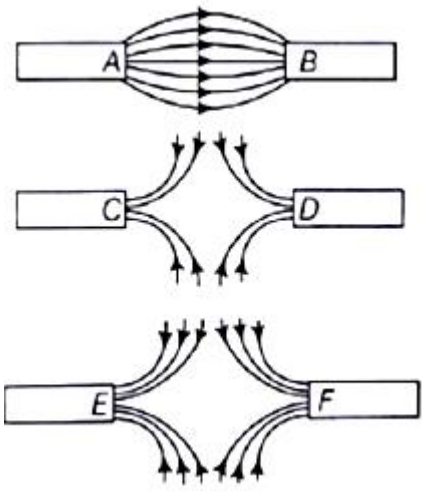
Explain the following observations:

(i) Bulb lights and
(ii) bulb gets dimmer, if the coil P is moves upwards.

Answer: (i) The bulb lights due to the mutual induction. The emf is produced in the conductor when the magnetic flux linked with the conductor changes. Due to this emf the bulb gets lighted.

(ii) When the coil P is move upwards the magnetic flux linked with the coil gets decreased due to which the induced emf gets decreased, hence the bulb gets dimmer.

Q. 9. Three diagrams in the following figures show the magnetic field lines between the poles of the magnets. Identify the poles between A,B,C,D,E and F.



Answer: (i) A is North Pole and B is South Pole because magnetic field lines originate from North Pole and ends at South Pole.

(ii) C and D are South Pole because the magnetic field lines end at the South Pole and same type of poles repel each other.

(iii) E and F are South Pole because the magnetic field lines end at the South Pole and same type of poles repel each other.

Q. 10. Why does a magnetic compass needle pointing North and South in the absence of a nearby magnet gets deflected when a bar magnet or a current carrying loop is brought near it. Describe some salient features of magnetic field lines concept.

Answer: A magnetic compass needle pointing North and South shows deflection when a bar magnet or a current carrying loop is brought near it. This happens because the magnetic fields of the compass needle and the bar magnet (or current carrying loop) interact with each other.

Salient features of magnetic field lines:-

a. Magnetic field lines follow the direction from the North Pole to the South Pole.

b. Magnetic field lines always show concentric pattern.

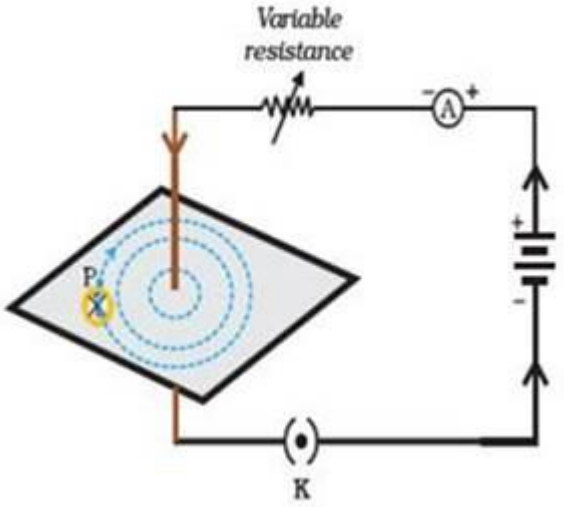
c. Magnetic field lines do not cross one another.

d. Closer the field lines; stronger is the magnetic field and vice-versa is also true.

e. Magnetic field lines are closer near the poles; which shows greater strength of magnetic field near the poles.

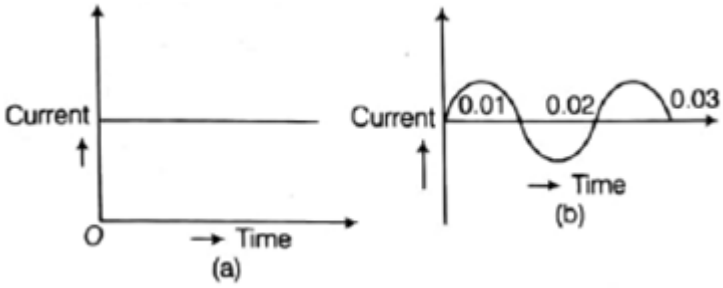
Q. 11. With the help of a labelled circuit diagram illustrate the pattern of field lines of the magnetic field around a long current carrying straight conducting wire. How is the right hand thumb rule useful to find direction of magnetic field associated with a current carrying conductor?

Answer: The magnetic field lines around a straight conductor (straight wire) carrying current are concentric circles whose centers lie on the wire. Figure below shows the field lines.



Right hand thumb rule states that if a current carrying straight conductor is supposedly held in the right hand with the thumb pointing towards the direction of current, then the fingers will wrap around the conductor in the direction of the field lines of the magnetic field.

Q. 12. You are given the following current- time graphs from two different sources:



Now, answer the following questions:

(i) Name the type of current in two cases.
(ii) Identify any one source for each type of these currents.

(iii) What is the frequency of current in case (b) in India?
(iv) Use above graphs to write two differences between the current in two cases.

Answer: (i) The current in first case is the **Direct current** because it is constant with the time. The current in second case is the **Alternating current** because its direction and magnitude changes continuously with the time.

(ii) Source of direct current are solar cell, fuel cell etc.

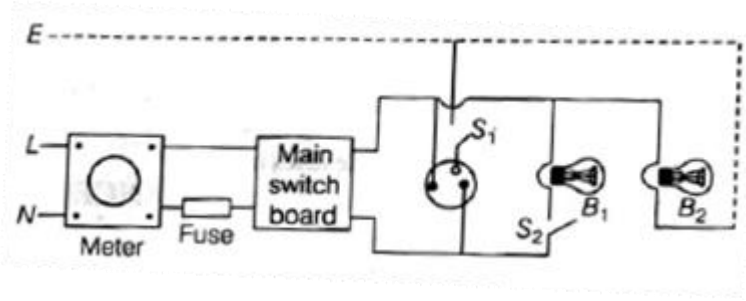
Source of alternating current the electricity coming to our home.

(iii) The frequency of the Alternating current in India is **50 Hz.**

(iv)

Alternating current	Direct current
1. The frequency of alternating current is 50Hz or 60Hz depending upon the country.	The frequency of direct current is Zero.
2. It is the current of magnitude varying with time	It is the current of constant magnitude.

Q. 13.



(i) The figure shows a domestic electric circuit. Study this circuit carefully and list any three errors in the circuit and justify your answer.

(ii) Give one difference between the wires used in the element of an electric heater and in a fuse.

(iii) List two advantages of parallel connection over series connection.

Answer:

(i) Following are the errors in the circuit given above.

a) Fuse is incorrectly connected to the Neutral wire (N) it must be connected to the live wire (L).

b) Bulb B2 is not connected to the neutral wire.

(ii) Element of electric heater has high melting point in order to stand high temperatures while element of fuse has low melting point.

(iii) 1. Each appliance will have and equal potential difference.

2. Each appliance will have a separate switch to ON/OFF the flow of the current.

Q. 14. Overloading in an electric circuit causes fire. Many people are unaware of this fact. Amit, an intelligent student told people of his building about overloading. He told them various precautions to avoid it questions:

(i) What harm does overloading in the circuit cause?
(ii) What values are shown by Amit?

Answer: (i) Overloading can lead to damage, poor performance and possible failure. There may be a risk of fire or damage to components. It can also lead to sparks, arcs or insulation failure. Current overload will cause things to heat up, and then possibly melt, set of fire, damage insulation or cause components to fail. Some components will be damaged by the excessive current without overheating

(ii) Amit is very caring and worried towards his society and people. He is also quite ware and intelligent. He uses his knowledge of science for helping society which is the sole purpose of education.

Q. 15. Raja had gone to his aunt's home in a foreign country, where domestic electric supply is DC. An electrician working in her kitchen was trying to locate the electric wiring in a particular wall for some electrical work but failed to do so. Electrician, then suggested the breaking of substantial position of wall to Rajat's aunt.

But Rajat told his aunt that he could locate the position of current carrying wires in the kitchen without any breakage. He brought a small device from market and within ten minutes, located the position of all current carrying wires on wall of his aunt got very happy from him.

Read the above passage and answer the following questions:

(i) Which device was purchased by Rajat?
(ii) What was noticed by Rajat when he moved this device slowly over the current carrying wires embedded kitchen?
(iii) What values are shown by Rajat in this episode?

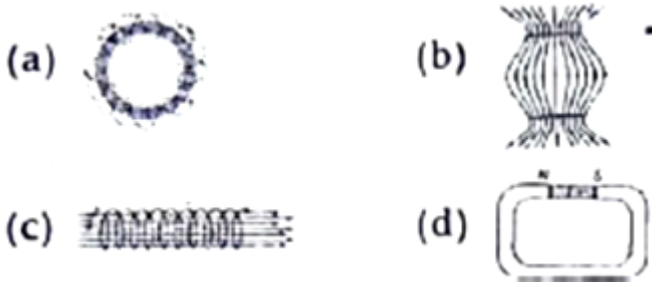
Answer: (i) Rajat has purchased a Compass because it contains the magnet and in presence of the electric current the needle in it deflects which helps in detecting the current carrying wires. Figure below shows the compass.

(ii) Rajat noticed the deflection in the needle of the compass when he was moving the device slowly over the wires. Actually due to interaction between the magnetic field of the compass and of the current carrying wires the deflection is produced.

(iii) Rajat is very aware and clever. He quickly brought the instrument to help his aunt this shows he is very helping and caring towards his aunt.

Challengers

Q. 1. Which of the following figures shows the correct magnetic field lines?

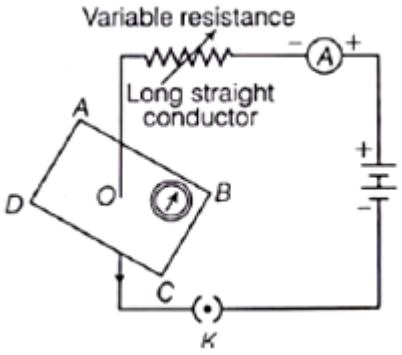


A. (a)
B. (b)
C. (c)
D. (d)

Answer: In option A the magnetic field lines are circular; also they start and end at definite point.

But in option D the magnetic field lines are shown as square in shape therefore it is incorrect. In option B and C they are not starting and ending at definite point.

Q. 2. If the key in the arrangement as shown below is taken out (the circuit is made open) and magnetic field lines are drawn over the horizontal plane ABCD, the lines are



A. Concentric circles
B. elliptical in shape
C. Straight lines parallel to each other
D. Concentric circles near the point O but of elliptical shapes as we go away from it

Answer: Since the key is taken out due to which there is no magnetic field due to wire. Hence only magnetic field of earth is present and the magnetic field lines of the earth are straight lines parallel to each other.

Q. 3. Three plotting compasses are to a solenoid carrying a current. How many of the compass needles will change direction, if the current through the solenoid is increased?

(Ignore the effect of the earth's magnetic field).

A. Only I compass needle
B. 2 compass needle
C. 3 compass needle
D. None of the above

Answer: Since the magnetic field outside the solenoid is zero because it gets cancelled due to the each circular ring. Hence no compasses will get deflected.

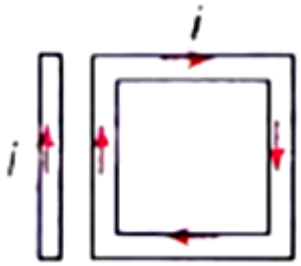
Q. 4. A ship is to reach a place 8° south of west. In what direction should the ship be steered if declination at the place is 18° west?

A. West of magnetic north at angle 64°
B. East of magnetic south at angle 64°

C. West of magnetic south at angle 50°
D. East of magnetic north at angle 18°

Answer: Initially the ship is at 8° south of west. Declining 180 from 80 south of west results in actual direction. Now from north we get the direction of 90-18-8 = 90-26 = 64° West of North.

Q. 5. A rectangular loop carrying a current is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If a steady current its created in wire as shown in figure below, then the loop will.



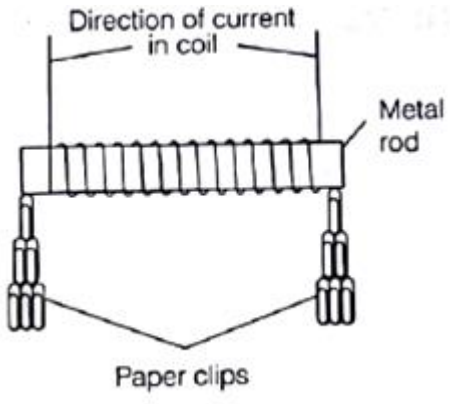
A. rotate about an axis parallel to the wire
B. move towards the wire
C. move away from the wire or towards right
D. remains stationary

Answer: For the loop, using Lenz's Law, the force on the part which is nearer, due to the current in the long wire is attraction and force on the part which is farther is repulsion.

F (attraction) > F (repulsion)

Hence loop moves towards the wire.

Q. 6. Four metal rods are placed, in turn, inside a coil of copper wire,



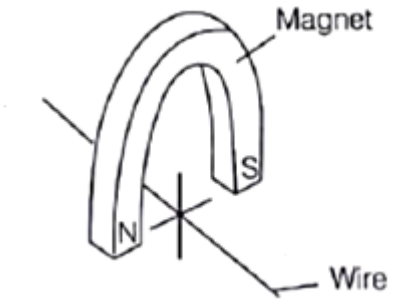
The table below gives the results of the experiment. Which rod would be the most suitable to use for the case of a coil in a circuit breaker?

Metal rod	Number of paper clips picket up when there is a current in the coil	Number of paper clips still attracted when the current is switched off
(a)	1	0
(b)	20	2
(c)	35	0
(d)	35	30

A. (a)
B. (b)
C. (c)
D. (d)

Answer: The core of solenoid must be of some soft type magnetic material which can be strongly magnetized but does not retain induced magnetism.

Q. 7. A cooper 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?

A. 1
B. 2
C. 3
D. 4

Answer: The force on the wire due to the interaction of magnetic fields of the bar magnet and current carrying wire can act only in upwards or downwards direction.