**Magnetic Effect of Electric Current**

**Electromagnetic Effect**

Similar to other effects; electric current also produces magnetic effect. The magnetic effect of electric current is known as electromagnetic effect.

It is observed that when a compass is brought near a current carrying conductor the needle of compass gets deflected because of flow of electricity. This shows that electric current produces a magnetic effect.

Properties of magnet:

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

Magnetic field and Field Lines



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

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

Direction of Field Line:- Outside the magnet, the direction of magnetic field line is taken from north pole to South Pole. Inside the magnet, the direction of magnetic field line is taken from south pole to north pole.

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

Magnetic field Due to a Current Carrying Conductor:

Magnetic field due to current through a straight conductor:-

 

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

The direction of magnetic field through a current carrying conductor depends upon the direction of flow of electric current. The direction of magnetic field gets reversed in case of a change in the direction of electric current.

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

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

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



As per Maxwell’s corkscrew rule, if the direction of forward movement of screw shows the direction of current, then the direction of rotation of screw shows the direction of magnetic field.



Properties of Magnetic Field:

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

Magnetic field due to current through a circular loop:



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

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

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

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

Magnetic field and number of turns of coil:

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

Magnetic Field due to a current in a Solenoid:

Solenoid is the coil with many circular turns of insulated copper wire wrapped closely in the shape of cylinder.

A current carrying solenoid produces similar pattern of magnetic field as a bar magnet. One end of solenoid behaves as the north pole and another end behaves as the south pole. Magnetic field lines are parallel inside the solenoid; similar to a bar magnet; which shows that magnetic field is same at all points inside the solenoid.

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

# Magnetic Effect of Electric Current

## Force on a current carrying conductor in a magnetic field:

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

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

### Fleming’s Left Hand Rule:-

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

Many devices, such as electric motor, electric generator, loudspeaker, etc. works on the Fleming’s left Hand Rule.

#### Electric Motor:-

#### electric motor

Electrical energy is converted into mechanical energy by using an electric motor. Electric motor works on the basis of rule suggested by Marie Ampere and Fleming’s Left Hand Rule.

In an electric motor, a rectangular coil is suspended between the two poles of a magnetic field. The electric supply to the coil is connected with a commutator. Commutator is a device which reverses the direction of flow of electric current through a circuit.

When electric current is supplied to the coil of electric motor, it gets deflected because of magnetic field. As it reaches the half way, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of current reverses the direction of forces acting on the coil. The change in direction of force pushes the coil; and it moves another half turn. Thus, the coil completes one rotation around the axle. Continuation of this process keeps the motor in rotation.

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

##### Electromagnetic Induction

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

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

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

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

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

###### Electric generator:

###### electric generator

The structure of electric generator is similar to that of an electric motor. In case of an electric generator a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in way that it can move around an axle. When the armature moves within the magnetic field an electric current is induced. The direction of induced current changes, when the armature crosses the halfway mark of its rotation. Thus, the direction of current changes once in every rotation. Due to this, the electric generator usually produces alternate current, i.e. AC. To convert an AC generator into a DC generator, a split ring commutator is used. This helps in producing direct current.

AC and DC current:

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

DC – Direct current:- Current that flows in one direction only is called Direct current. Electrochemical cells produce direct current.

**Magnetic Effect of Electric Current**

Question: 1 - Why does a compass needle get deflected when brought near a bar magnet?

Answer: When a compass needle is brought near a bar magnet, the compass needle experiences a deflection. This happens because of interaction of magnetic fields of the compass needle and the bar magnet.

Question: 2 - Draw magnetic field lines around a bar magnet.

Answer:



Question: 3 :- List the properties of magnetic lines of force.

Answer: Properties of magnetic field lines:

1. Magnetic field lines follow the direction from the north pole to the south pole.
2. Magnetic field lines always show concentric pattern.
3. Magnetic field lines do not cross one another.
4. Closer the field lines; stronger is the magnetic field and vice-versa is also true.
5. Magnetic field lines are closer near the poles; which shows greater strength of magnetic field near the poles.

Question: 4 :- Why don’t two magnetic lines of force intersect each other?

Answer: The direction of magnetic field lines is always from the north pole to the south pole. If the field lines would cross each other then the direction of field line would change at the point of crossing which is practically impossible. Hence, two magnetic field lines never intersect each other.

Question: 5 :- Consider a circular loop of wire lying in the plane of the table. Let the current pass through the loop clockwise. Apply the right hand rule to find out the direction of the magnetic field inside and outside the loop.

Answer: As the given figure shows; current is flowing clockwise through a circular loop. The direction of magnetic field around the conductor can be known by using the right hand thumb rule. As the figure shows, the magnetic field would be towards the plane of the paper when it is inside the loop. On the other hand, the magnetic field would be away from the paper when it is outside the loop.



Question: 6 :- The magnetic field in a given region is uniform. Draw a diagram to represent it.

Answer:



Question: 7 :- Choose the correct option.

The magnetic field inside a long straight solenoid-carrying current

1. Is zero.
2. Decreases as we move towards its end.
3. Increases as we move towards its end.
4. Is the same at all points.

Answer: (d) Is the same at all points.

Question: 8 :- Which of the following property of a proton can change while it moves freely in a magnetic field? (There may be more than one correct answer)

1. Mass
2. Speed
3. Velocity
4. Momentum

Answer: (c) and (d), i.e. velocity and mass of proton change when it enters a magnetic field. When a proton enters a magnetic field it starts moving on a circular path. Because of its movement along a circular path it attains angular momentum. We know that momentum is a product of mass and velocity.

Question: 9 - In Activity 13.7, how do we think the displacement of rod AB will be affected if (i) current in rod AB is increased; (ii) a stronger horse-shoe magnet is used; and (iii) length of the rod AB is increased?

Answer: In this case, the displacement would vary directly as the strength of current, strength of magnetic field and length of the conductor. Due to this, the displacement of conductor would be increased in all the three cases.

Question: 10 - A positively-charged particle (alpha-particle) projected towards west is deflected towards north by a magnetic field. The direction of magnetic field is

1. Towards south
2. Towards east
3. Downward
4. Upward

Answer:- This question can be solved by using Fleming’s Left Hand Rule. We know that the direction of current is opposite to the direction of electron’s movement and hence it would be same as the direction of proton’s movement. So, the direction of current is towards west. As per Fleming’s Left Hand Rule; the middle finger shows the direction of current, the forefinger shows the direction of magnetic field and the thumb shows the direction of motion. Here, the deflection is towards north, i.e. in north westerly direction and hence, the direction of magnetic field would be towards north, i.e. upward.

Question: 11 :- State Fleming’s Left Hand Rule.

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

Question: 12 :- What is the principle of an electric motor?

Answer: Principle of Electric Motor: The electric motor works on the principle of Fleming’s Left Hand Rule. When a rectangular coil is placed within a magnetic field and current is passed through the coil, there is deflection in the coil. The deflection changes into rotation of coil because of split ring commutator in the motor.

Question: 13 :- What is the role of a split ring in an electric motor?

Answer: In an electric motor, after every half rotation the direction of coil gets reversed due to change in orientation of the magnetic field. To ensure a continuous rotation; a split ring is attached to the coil so that the polarity of the coil changes after every half rotation. This changes the direction of current and thus the armature keeps on rotating continuously.

Question: 14 - Explain different ways to induce current in a coil.

Answer: For electromagnetic induction; the coil and the magnet should be in relative motion. This can be ensured by any of the following two ways:

1. The coil should be moved within a magnetic field.
2. The magnet should be moved and coil can be kept static.

Question: 15 - State the principle of an electric generator.

Answer: Electric Generator works on the principle of electromagnetic induction which obeys Fleming’s Right Hand Rule. When coil is moved inside a magnetic field a current is induced in the coil. The electric current is thus ‘generated’ by electric generator.

Question: 16 - Name some sources of direct current.

Answer: Electrochemical cell, DC generator, photovoltaic cell, etc.

Question: 17 - Which sources produce alternating current?

Answer: AC generator

Question: 18 - Choose the correct option.

A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each

1. two revolutions
2. one revolution
3. half revolution
4. one-fourth revolution

Answer: (c) Half revolution

Question: 19 - Name two safety measures commonly used in electric circuits and appliances.

Answer: Earth wire and electric fuse

Question: 20 - An electric oven of 2 kW is operated in a domestic electric circuit (220 V) that has a current rating of 5 A. What results do you expect? Explain.

Answer: The current drawn by the electric oven can be calculated using following formula:



Here, the oven is drawing 9.09 ampere of current from a 5 ampere source.

This means there would be an overload on the circuit. This can result in accidental fire in the circuit.

Question: 21 - What precaution should be taken to avoid the overloading of domestic electric circuits?

Answer: Precautions to avoid overloading of domestic electric circuit:

1. Avoid using too many appliances in a single line, i.e. from a single output.
2. Appliances should always be checked for potential faults and should be repaired in time.
3. Fuse or MCB of proper rating should be used.

Question: 1:- Which of the following correctly describes the magnetic field near a long straight wire?

1. The field consists of straight lines perpendicular to the wire.
2. The field consists of straight lines parallel to the wire.
3. The field consists of radial lines originating from the wire.
4. The field consists of concentric circles centred on the wire.

Answer: (d) The field consists of concentric circles centred on the wire.

Question: 2 :- The phenomenon of electromagnetic induction is

1. The process of charging a body.
2. The process of generating magnetic field due to a current passing through a coil.
3. Producing induced current in a coil due to relative motion between a magnet and the coil.
4. The process of rotating a coil of an electric motor.

Answer:- (c) Producing induced current in a coil due to relative motion between a magnet and the coil.

Question: 3 :- The device used for producing electric current is called a

1. Generator.
2. Galvanometer.
3. Ammeter.
4. Motor.

Answer: (a) Generator

Question: 4 :- The essential difference between an AC generator and a DC generator is that

1. AC generator has an electromagnet while a DC generator has permanent magnet.
2. DC generator will generate a higher voltage.
3. AC generator will generate a higher voltage.
4. AC generator has slip rings while the DC generator has a commutator.

Answer: (d) AC generator has slip rings while the DC generator has a commutator.

Question: 5 :- At the time of short circuit, the current in the circuit

1. Reduces substantially.
2. Does not change.
3. Increases heavily.
4. Vary continuously.

Answer: (c) Increases heavily

Question: 6 - State whether the following statements are true or false.

1. An electric motor converts mechanical energy into electrical energy.
2. An electric generator works on the principle of electromagnetic induction.
3. The field at the centre of a long circular coil carrying current will be parallel straight lines.
4. A wire with a green insulation is usually the live wire of an electric supply.

Answer: (a) F (b) T (c) T (d) F

Question: 7 - List three methods of producing magnetic fields.

Answer: Three methods of producing magnetic fields are as follows:

1. By permanent magnet
2. By electromagnet
3. By current carrying conductors

Question: 8 - How does a solenoid behave like a magnet? Can you determine the north and south poles of a current–carrying solenoid with the help of a bar magnet? Explain.

Answer: A solenoid begins behaving like a magnet when electric current flows through it. We know that any current carrying conductor creates a magnetic field around it and that is what happens in case of solenoid. For determining the different poles of a solenoid, we can use a bar magnet and look for interaction between different poles of two magnets. If the north pole of the bar magnet gets repulsed by a particular pole of the electromagnet (solenoid) then it gets confirmed that the bar magnet was brought near the north pole of the electromagnet.

Question: 9 - When is the force experienced by a current–carrying conductor placed in a magnetic field largest?

Answer: From Fleming’s Left Hand Rule, it is clear that when the direction of current and magnetic field are in mutually perpendicular directions, the deflection in conductor is the maximum. This shows that when magnetic field and direction of current are perpendicular to each other, the force experienced by the conductor is the largest.

Question: 10 - Imagine that you are sitting in a chamber with your back to one wall. An electron beam, moving horizontally from back wall towards the front wall, is deflected by a strong magnetic field to your right side. What is the direction of magnetic field?

Answer: Here, the electron beam is moving towards the viewer, i.e. out of the plane of the page. This means that the direction of current is towards the page. This shows the direction in which the forefinger is pointing. The thumb is pointing towards right which is same as the direction of deflection. The middle finger is pointing downwards; which shows the direction of the magnetic field.

### electromagnet 3

Question: 11 - Draw a labelled diagram of an electric motor. Explain its principle and working. What is the function of a split ring in an electric motor?

Answer:-

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Working of Electric Motor:



Electrical energy is converted into mechanical energy by using an electric motor. Electric motor works on the basis of rule suggested by Marie Ampere and Fleming’s Left Hand Rule.

In an electric motor, a rectangular coil is suspended between the two poles of a magnetic field. The electric supply to the coil is connected with a commutator. Commutator is a device which reverses the direction of flow of electric current through a circuit.

When electric current is supplied to the coil of electric motor, it gets deflected because of magnetic field. As it reaches the half way, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of current reverses the direction of forces acting on the coil. The change in direction of force pushes the coil; and it moves another half turn. Thus, the coil completes one rotation around the axle. Continuation of this process keeps the motor in rotation.

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

Question: 12 :- Name some devices in which electric motors are used.

Answer: Electric fan, mixer grinder, tape recorder, CD player, hard disk drive, washing machine, cooler, toy car, vacuum cleaner, etc. are some devices in which electric motor is used.

Question: 13 :- A coil of insulated copper wire is connected to a galvanometer. What will happen if a bar magnet is (i) pushed into the coil, (ii) withdrawn from inside the coil, (iii) held stationary inside the coil?

Answer: When the bar magnet is pushed into the coil or withdrawn from the coil; the galvanometer needle would show deflection. When the bar magnet is kept stationary inside the coil; the galvanometer needle would show no deflection.

Question: 14 :- Two circular coils A and B are placed close to each other. If the current in the coil A is changed, will some current be induced in the coil B? Give reason.

Answer: When two circular coils A and B are placed close to each other and the current in coil A is changed, it leads to induction of current in coil B. This happens because of change in magnetic field of coil A; because of change in current in this coil.

Question: 15 :- State the rule to determine the direction of a (i) magnetic field produced around a straight conductor-carrying current, (ii) force experienced by a current-carrying straight conductor placed in a magnetic field which is perpendicular to it, and (iii) current induced in a coil due to its rotation in a magnetic field.

Answer:

1. Right hand thumb rule or Maxwell’s corkscrew rule,
2. Fleming’s Left Hand Rule and
3. Fleming’s Right Hand Rule

Question: 16 - Explain the underlying principle and working of an electric generator by drawing a labelled diagram. What is the function of brushes?

Answer:



The structure of electric generator is similar to that of an electric motor. In case of an electric generator a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in way that it can move around an axle. When the armature moves within the magnetic field an electric current is induced.

The direction of induced current changes, when the armature crosses the halfway mark of its rotation. Thus, the direction of current changes once in every rotation. Due to this, the electric generator usually produces alternate current, i.e. AC.

To convert an AC generator into a DC generator, a split ring commutator is used. This helps in producing direct current.

Question: 17 - When does an electric short circuit occur?

Answer: When positive and negative wires touch each other, the resistance suddenly decreases and current increases. This leads to excessive heating of wire which manifests in the form of sparks. This is called short circuit.

Question: 18 - What is the function of an earth wire? Why is it necessary to earth metallic appliances?

Answer: The earth wire transfers any leakage of electric current to the earth. The leaked current can otherwise reach the metallic body of an appliance and can lead to electric shock. Earth wire prevents from electric shock by safety transferring the leaked current to the earth.

###  Exemplar Solution - MCQ

Question: 1 :- Choose the incorrect statement from the following regarding magnetic lines of field

1. 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
2. Magnetic field lines are closed curves
3. If magnetic field lines are parallel and equidistant, they represent zero field strength
4. Relative strength of magnetic field is shown by the degree of closeness of the field lines

Answer:- (c) If magnetic field lines are parallel and equidistant, they represent zero field strength

Question: 2 :- If the key in the arrangement (Figure 13.1) is taken out (the circuit is made open) and magnetic field lines are drawn over the horizontal plane ABCD, the lines are



1. Concentric circles
2. Elliptical in shape
3. Straight lines parallel to each other
4. Concentric circles near the point O but of elliptical shapes as we go away from it

Answer:- (a) Concentric circles

Question: 3 - A circular loop placed in a plane perpendicular to the plane of paper carries a current when the key is ON. The current as seen from points A and B (in the plane of paper and on the axis of the coil) is anti clockwise and clockwise respectively. The magnetic field lines point from B to A. The N-pole of the resultant magnet is on the face close to



1. A
2. B
3. A if the current is small, and B if the current is large
4. B if the current is small and A if the current is large

Answer:- (a) A

Question: 4 - 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

1. 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
2. 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
3. The pattern of the magnetic field associated with the solenoid is different from the pattern of the magnetic field around a bar magnet
4. The N- and S-poles exchange position when the direction of current through the solenoid is reversed

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

Question: 5 :- Commercial electric motors do not use

1. An electromagnet to rotate the armature
2. Effectively large number of turns of conducting wire in the current carrying coil
3. A permanent magnet to rotate the armature
4. A soft iron core on which the coil is wound

Answer: (c) A permanent magnet to rotate the armature

Question: 6 :- A uniform magnetic field exists in the plane of paper pointing from left to right as shown in Figure 13.3. In the field an electron and a proton move as shown. The electron and the proton experience



1. Forces both pointing into the plane of paper
2. Forces both pointing out of the plane of paper
3. Forces pointing into the plane of paper and out of the plane of paper, respectively
4. Force pointing opposite and along the direction of the uniform magnetic field respectively

Answer: (c) Forces pointing into the plane of paper and out of the plane of paper, respectively

Question: 7 :- In the arrangement shown in Figure 13.4 there are two coils wound on a non-conducting cylindrical rod. Initially the key is not inserted. Then the key is inserted and later removed. Then



1. The deflection in the galvanometer remains zero throughout
2. There is a momentary deflection in the galvanometer but it dies out shortly and there is no effect when the key is removed
3. There are momentary galvanometer deflections that die out shortly; the deflections are in the same direction
4. There are momentary galvanometer deflections that die out shortly; the deflections are in opposite directions

Answer: (c) There are momentary galvanometer deflections that die out shortly; the deflections are in the same direction

Question: 8- Choose the incorrect statement

1. Fleming’s right-hand rule is a simple rule to know the direction of induced current
2. The right-hand thumb rule is used to find the direction of magnetic fields due to current carrying conductors
3. The difference between the direct and alternating currents is that the direct current always flows in one direction, whereas the alternating current reverses its direction periodically
4. In India, the AC changes direction after every 1/50 second

Answer: (d) In India, the AC changes direction after every 1/50 second

Question: 9 - A constant current flows in a horizontal wire in the plane of the paper from east to west as shown in Figure 13.5. The direction of magnetic field at a point will be North to South



1. Directly above the wire
2. Directly below the wire
3. At a point located in the plane of the paper, on the north side of the wire
4. At a point located in the plane of the paper, on the south side of the wire

Answer: (a) Directly above the wire

Question: 10- The strength of magnetic field inside a long current carrying straight solenoid is

1. More at the ends than at the centre
2. Minimum in the middle
3. Same at all points
4. Found to increase from one end to the other

Answer: (c) Same at all points

Question: 11 - To convert an AC generator into DC generator

1. Split-ring type commutator must be used
2. Slip rings and brushes must be used
3. A stronger magnetic field has to be used
4. A rectangular wire loop has to be used

Answer: (a) Split ring type commutator must be used

Question: 12- The most important safety method used for protecting home appliances from short circuiting or overloading is

1. Earthing
2. Use of fuse
3. Use of stabilizers
4. Use of electric meter

Answer: (b) Use of fuse

**Short Answer Type**

Question: 13 :- A magnetic compass needle is placed in the plane of paper near point A as shown in Figure 13.6. In which plane should a straight current carrying conductor be placed so that it passes through A and there is no change in the deflection of the compass? Under what condition is the deflection maximum and why?



Answer: We know that when the magnetic field and the direction of current are perpendicular to each other, the deflection is maximum. But when they are in the same plane, no deflection takes place. So, the current carrying conductor needs to be placed in the same plane as the magnetic compass to attain no deflection.

Question: 14:- Under what conditions permanent electromagnet is obtained if a current carrying solenoid is used? Support your answer with the help of a labelled circuit diagram.

Answer:-



We know that for making an electromagnet we need to place a soft iron core inside a solenoid. Soft iron is a ferro-magnetic material and hence it augments the magnetic property of solenoid by thousands of times. Thus, for making a permanent electromagnet, we need to place a soft iron core inside a solenoid.

Question: 15 :- AB is a current carrying conductor in the plane of the paper as shown in Figure 13.7. What are the directions of magnetic fields produced by it at points P and Q? Given r1 > r2, where will the strength of the magnetic field be larger?



Answer: Applying the right hand thumb rule, the direction of magnetic field would be anti-clockwise around the direction of current. So, the magnetic field would be to point P and towards the plane of paper. At point Q, the direction of magnetic current would be from the conductor and away from the plane of paper. Since magnetic field is stronger near the conductor and weaker as we move away from the conductor, so the magnetic field would be stronger near point Q than near point P.

Question: 16 :- 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? Support your answer with a reason.

Answer: The strength of magnetic field varies directly as the magnitude of the electric current. So, in case of an increase in current the magnetic field would increase.

Question: 17 - It is established that an electric current through a metallic conductor produces a magnetic field around it. Is there a similar magnetic field produced around a thin beam of moving (i) alpha particles, (ii) neutrons? Justify your answer.

Answer: It is a fact that in case of movement of a charged particle, magnetic field is created around the path on which the charged particle moves. Since alpha particles are positively charged so a magnetic field would be created around its path. But, as neutrons carry no charge so no magnetic field would be created around its path.

Question: 18- What does the direction of thumb indicate in the right-hand thumb rule. In what way this rule is different from Fleming’s left-hand rule?

Answer: As per right hand thumb rule, the thumb shows the direction of electric current. The right hand thumb rule explains the magnetic field created due to a current carrying conductor. On the other hand, Fleming’s left hand rule explains effect of magnetic field on a current carrying conductor.

Question: 19 - 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?

Answer: We know that the magnetic field is stronger near the current carrying conductor and tends to weaken as we move away from the conductor. In case of a current carrying circular loop, the magnetic field is stronger near the periphery but weaker near the centre of the loop. Due to this, the magnetic field lines appear as straight lines near the centre. As we move towards the periphery of the circular loop, the magnetic field lines appear to be diverging so that they can be circular around the wire of the loop.

Question: 20 - What does the divergence of magnetic field lines near the ends of a current carrying straight solenoid indicate?

Answer: We know that magnetic field lines make loop around a magnet. The solenoid behaves like a magnet and due to this, the magnetic field lines diverge. Due to this, the magnetic field is strongest near the ends of the solenoid and the ends become the poles of the magnet thus formed.

Question: 21 - Name four appliances wherein an electric motor, a rotating device that converts electrical energy to mechanical energy, is used as an important component. In what respect motors are different from generators?

Answer: Table fan, CD player, vacuum cleaner and hand blender are four examples of appliances in which an electric motor is used as an important component. Electric motors convert electrical energy into mechanical energy, while generators do the opposite. Electric motor works on the concept of Fleming’s Left Hand Rule; while generator works on the concept of Fleming’s Right Hand Rule.

Question: 22 - What is the role of the two conducting stationary brushes in a simple electric motor?

Answer: They keep the two poles of the armature in contact with the power supply.

Question: 23 - What is the difference between a direct current and an alternating current? How many times does AC used in India change direction in one second?

Answer: In case of AC; the direction of current keeps on changing at frequent intervals, while the direction of current always remains the same in case of DC. The AC in India changes its direction at the rate of 100 times in a second.

Question: 24 - 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?

Answer: We know that an electric fuse is a simple device which breaks the current in case of an overload. A fuse; used in series with an electrical appliance; helps in protecting that appliance from potential damage which may happen due to overload. A fuse wire works because of its lower melting point which is possible because of its respective rating. If a fuse with larger rating is used with an appliance, the fuse wire shall not melt and hence would fail to serve the required purpose. Due to this, a fuse with defined rating should not be replaced by one with a larger rating.

### Long Answer Type - part 1

Question: 25:- Why does a magnetic compass needle pointing North and South in the absence of a nearby magnet get deflected when a bar magnet or a current carrying loop is brought near it. Describe some salient features of magnetic lines of field 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:-

1. Magnetic field lines follow the direction from the north pole to the south pole.
2. Magnetic field lines always show concentric pattern.
3. Magnetic field lines do not cross one another.
4. Closer the field lines; stronger is the magnetic field and vice-versa is also true.
5. Magnetic field lines are closer near the poles; which shows greater strength of magnetic field near the poles.

Question: 26 :- With the help of a labelled circuit diagram illustrate the pattern of field lines of the magnetic field around a current carrying straight long conducting wire. How is the right hand thumb rule useful to find direction of magnetic field associated with a current carrying conductor?

Answer:- The following diagram depicts the pattern and direction of magnetic field lines around a straight current-carrying conductor.



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

Question: 27 :- Explain with the help of a labelled diagram the distribution of magnetic field due to a current through a circular loop. Why is it that if a current carrying coil has n turns the field produced at any point is n times as large as that produced by a single turn?

Answer: Magnetic Field Due to Circular Loop Current-Carrying Conductor: In case of a circular current carrying conductor, the magnetic field lines would be in the form of concentric circles around every part of the periphery of the conductor. Since, magnetic field lines tend to remain closer when near the conductor, so the magnetic field would be stronger near the periphery of the loop. On the other hand, the magnetic field lines would be distant from each other when we move towards the centre of the current carrying loop. Finally; at the centre, the arcs of big circles would appear as a straight lines.



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

Question: 28 :- Describe the activity that shows that a current-carrying conductor experiences a force perpendicular to its length and the external magnetic field. How does Fleming’s left-hand rule help us to find the direction of the force acting on the current carrying conductor?

Answer: Activity: To show the effect of magnetic field on current-carrying conductor

Materials Required: For this, we need to take a small aluminium rod, a horse-shoe magnet, battery, plug key, wires and a stand.

Procedure:

* The aluminium rod is suspended horizontally from the stand and tied to two wires at its ends. The wires are attached to rheostat, battery and a plug key to make the circuit.
* The horse-shoe magnet is positioned in a way that the aluminium rod lies between the two poles of the magnet.
* Let us assume that the south pole is above the aluminium rod and the north pole is below it. The plug key is inserted to initiate current supply to the rod.
* It is observed that the aluminium rod deflects towards left.
* When the direction of the current is reversed the aluminium rod deflects towards right.

Based on above observations, it can be said that when a current carrying conductor is placed within a magnetic field; the conductor experiences deflection. Fleming’s Left Hand Rule explains the direction of displacement in this case. Let us assume that the current is moving in anti-clockwise direction in the loop. In that case, the magnetic field would be in clockwise direction; at the top of the loop. Moreover, it would be in anticlockwise direction at the bottom of the loop.

### Long Answer Type - part 2

Question: 29 - Draw a labelled circuit diagram of a simple electric motor and explain its working. In what way these simple electric motors are diffferent from commercial motors?

Answer: Working of Electric Motor:-



Electrical energy is converted into mechanical energy by using an electric motor. Electric motor works on the basis of rule suggested by Marie Ampere and Fleming’s Left Hand Rule.

In an electric motor, a rectangular coil is suspended between the two poles of a magnetic field. The electric supply to the coil is connected with a commutator. Commutator is a device which reverses the direction of flow of electric current through a circuit.

When electric current is supplied to the coil of electric motor, it gets deflected because of magnetic field. As it reaches the half way, the split ring which acts as commutator reverses the direction of flow of electric current. Reversal of direction of current reverses the direction of forces acting on the coil. The change in direction of force pushes the coil; and it moves another half turn. Thus, the coil completes one rotation around the axle. Continuation of this process keeps the motor in rotation.

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

Question: 30 :- Explain the phenomenon of electromagnetic induction. Describe an experiment to show that a current is set up in a closed loop when an external magnetic field passing through the loop increases or decreases.

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



Activity:- Demonstrating electromagnetic induction

Materials Required: For this, take a galvanometer, coil, bar magnet and some wires.

Procedure:-

* The coil is inserted over a hollow tube of cardboard.
* With the help of wires, the two ends of the coil are attached to the galvanometer.
* The north pole of the bar magnet is moved towards the end ‘B’ of the coil.
* It is observed that the galvanometer needle shows deflection to right.
* When the magnet is moved away from the coil, the galvanometer needle shows deflection towards left.
* When the magnet is in static position, no deflection is seen in galvanometer needle.
* Induction of electric current in the coil is the cause of deflection in galvanometer needle.
* If the magnet is kept stationary and coil is moved; then also the galvanometer needle shows deflection.

It can be concluded that when the coil and the bar magnet are in relative motion, a current is induced in the coil.

Question: 31 - Describe the working of an AC generator with the help of a labeled circuit diagram. What changes must be made in the arrangement to convert it to a DC generator?

Answer:



The structure of electric generator is similar to that of an electric motor. In case of an electric generator a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in way that it can move around an axle. When the armature moves within the magnetic field an electric current is induced.

The direction of induced current changes, when the armature crosses the halfway mark of its rotation. Thus, the direction of current changes once in every rotation. Due to this, the electric generator usually produces alternate current, i.e. AC.

To convert an AC generator into a DC generator, a split ring commutator is used. This helps in producing direct current.

Question: 32 - Draw an appropriate schematic diagram showing common domestic circuits and discuss the importance of fuse. Why is it that a burnt out fuse should be replaced by another fuse of identical rating?

Answer:

Importance of Fuse: The electric fuse is an important device in household wiring and also in many electrical appliances. By melting, the fuse wire breaks the circuit and thus helps in saving the wiring or the appliance from damage.

A fuse wire works because of its lower melting point which is possible because of its respective rating. If a fuse with larger rating is used with an appliance, the fuse wire shall not melt and hence would fail to serve the required purpose. Due to this, a fuse with defined rating should not be replaced by one with a larger rating.

