

MAGNETIC EFFECT OF ELECTRIC CURRENT

MAGNETISM

The property due to which a substance attracts pieces of iron, nickel and cobalt towards itself, is called magnetism. A naturally occurring iron ore (black iron oxide – Fe_2O_3) having properties of attracting iron pieces, was found in Magnesia in the upper part of Greece. The name magnetism has been taken from the name of that place.

The substance having property of magnetism, is called magnetic substance and body up of a magnetic substance, is called a magnet.

Magnets are found in various shapes and sizes. A bar magnet is a long rectangular bar uniform cross-section, which can attract pieces of iron, steel, cobalt and. Magnet can be natural or artificial.

Poles of a magnet: When a magnet is dipped in iron filings, then maximum filings stick to its ends and almost no filings stick to its centre. It means that in magnets, centers of attraction are located near the ends only. These centers of attraction near the ends of a magnet are called poles. Since a magnet has two poles hence it is also called magnetic dipole.

When this magnet is freely suspended, its two ends point in north south direction. The pole near the end pointing towards North (north-seeking end) is called North Pole. The pole near the end pointing towards South (south-seeking end) is called South Pole.

The magnetic poles exert forces on each other. Like poles repel each other, i.e., a north pole will repel another north pole or a south pole will repel another south pole. Unlike poles attract each other, i.e., a south pole will attract a north pole and vice versa.

Magnetic field of earth: Earth behaves as a huge magnet (or a giant solenoid). The source of this huge magnetism is given as the molten charged metallic giving rise to a current flowing inside the core of the earth. This core has a radius of about 3500 km (Earth's radius is 6400 km). Its strength is of the order of one gauss. Shape of the earth's magnetic field resembles with that of a bar magnet of length one fifth of earth's diameter buried at its centre.

Now it is believed that earth's magnetism is due to the magnetic effect of current which is flowing in the molten core at the centre of earth. Hence, earth is a huge electromagnet.

MAGNETIC FIELD AND MAGNETIC FIELD LINES (MAGNETIC LINES OF FORCE)

MAGNETIC FIELD

It is the space around a magnetic pole or a magnet in which its effect is experienced by another magnetic pole or magnet. Magnetic field is a quantity which has both direction and magnitude.

MAGNETIC LINES OF FORCE

A magnetic line of force is a line, straight or curved, in the magnetic field tangent to which at any point gives the direction of the magnetic field at that point.

OR

A line such that the tangent at any point on it gives the direction of the magnetic field at that point is called a magnetic field or magnetic line of force.

A free unit North Pole (test pole) will move along the magnetic line of force in direction of the field if it is free to do so. Direction of the magnetic line of force at any point is the direction of the force acting on unit (north) pole (unit magnetic pole) when placed at that point. Since a free unit North Pole (test pole) will move away from a north (N) pole, magnetic lines of

force have outward direction [Fig. (a)]. Since the free unit north pole will move towards a south (S) pole, magnetic lines of force have inward direction [Fig. (b)]. A small magnetic compass when moved along the lines of force always sets itself parallel to the line of force.

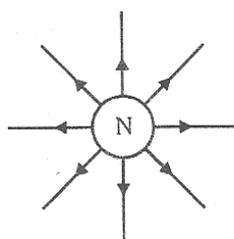


Fig.(a) due to north pole

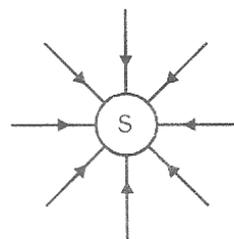
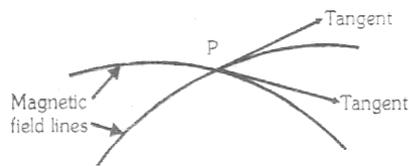


Fig.(b) due to south pole

Magnetic lines of force have the following properties:

1. All field lines are closed curves. They come out of magnet from the side of the North Pole and go into it on the side of the South Pole. i.e. They start from a north (positive) pole and end at a south (negative) pole. They continue inside the magnet too. Inside the magnet the direction of field lines is from its south pole to its north pole.
2. They are always normal to the surface of the magnet at every point.
3. Two lines of force do not intersect each other. If they intersect at a point, it would mean compass needle placed at the point of intersection would point towards two directions at that point which are not possible.



4. The field lines are close together near the poles and spread out away from them. The field is stronger where the field lines are more closely spaced. So the field is stronger near the poles than at other point.
5. The number of magnetic lines of force passing normally per unit area about a point gives the intensity of the magnetic field at that point.

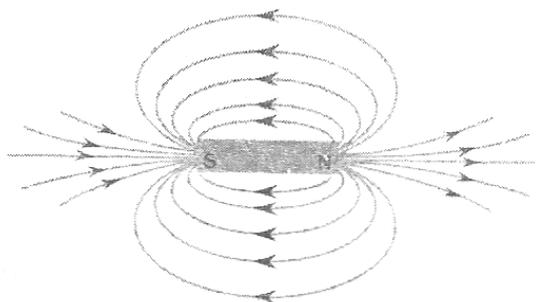


Fig. Magnetic field lines around a bar magnet

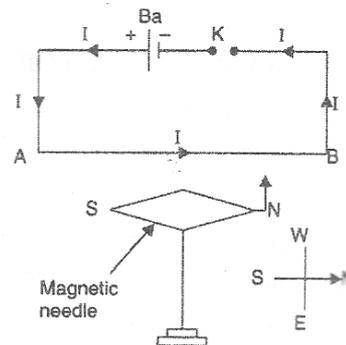
MAGNETIC FIELD DUE TO ELECTRIC CURRENT (OERSTED'S EXPERIMENT)

Oersted (1820) was the first to discover the magnetic effect of current, He found that if a compass needle is placed near a current carrying wire, needle gets deflected. He said that as compass needle is a tiny magnet and can be deflected only by some other magnetic field, hence a current carrying wire produces some magnetic field around itself. Magnetic effect of current is also known as electromagnetism. Magnetic effect of current is very useful in electric motors, generators, telephone etc.

Experimental arrangement used by Oersted is shown in Fig.

A straight wire AB is connected to a battery Ba and key K. The wire is held horizontally north-south over a magnetic needle. In this arrangement, when key is closed, current flows in the wire in the direction as shown in Fig. The north pole of the needle gets deflected towards west. When key is taken out and current in the wire becomes zero and the needle returns back to its initial position (S – N). This shows that a magnetic field is associated with an electric current.

When direction of current in the wire is reversed, direction of deflection of needle also gets reversed. If direction of current is kept same and the wire is put under the needle then, direction of deflection of needle again gets reversed.



Amount of deflection depends on the distance of the needle from the current carrying wire.

But we know that a magnetic needle is deflected by a magnetic field only. Hence we can conclude that current flowing in a wire gives rise to some magnetic field around it.

Position of the wire (conductor) carrying the current, direction of current and direction of deflection of the needle can be related by SNOW rule given below.

If current flows in the conductor from South towards North, with conductor kept over the needle, then North pole of the needle will be deflected towards West.

MAGNETIC FIELD DUE TO CURRENT CARRYING STRAIGHT

CONDUCTOR (WIRE) AND CURRENT CARRYING CIRCULAR COIL

Case 1. When Current carrying conductor is straight, Magnetic Field is Circular.

It means that when the current flows in a straight wire, the magnetic field produced has circular lines of force surrounding the wire, having their centres at the wire as shown in Fig. This can be shown by sprinkling iron filings on the cardboard C. When current flows through the conductor, iron filings get magnetised and now if the cardboard C is tapped gently iron filings arrange themselves in circles around the wire. Hence we can say that magnetic lines of force around a straight current carrying conductor are circular. The plane of circular lines is perpendicular to the length of the wire. Their direction is marked by arrows.

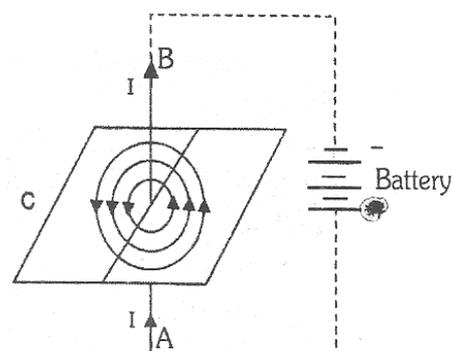


Fig. Current straight, magnetic field circular

When current I flow through a straight wire, the magnetic field strength (B) at a small distance r from it is given by

$$B = \frac{\mu_0 I}{2\pi r}$$

From the above expression we see that magnitude of magnetic produced by a straight carrying wire at a given point is:

- (i) directly proportional to the quantity of current flowing through the wire.
- (ii) inversely proportional to the distance of point from the wire. Thus, if current is more, magnetic field will be stronger and vice versa.

DIRECTION OF MAGNETIC FIELD

The direction of the magnetic lines of force is related with the direction of the current by the **right hand thumb rule**.

This rule states that:

Curl the four fingers of the right hand on the palm, keeping the thumb stretched out at right angles. The thumb is straight and the fingers are circular, then

- (i) **If thumb represents the direction of the current in the straight wire then curling of fingers represents the direction of the circular magnetic lines of force. (Fig. (a))**
- (ii) **If curled fingers represent the direction of the current in circular wire then thumb represents the direction of the straight magnetic lines of force. (Fig. (b))**

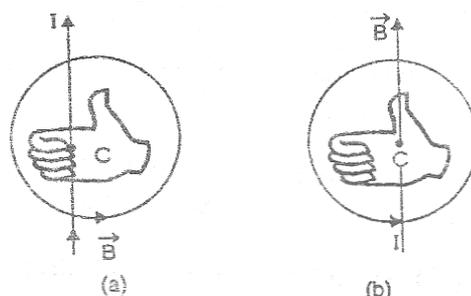


Fig. Right hand thumb rule for direction of magnetic field.

Maxwell's right hand thumb rule is also known as Maxwell cork screw rule. Cork screw is a device consisting of a handle and a spiral metal rod as shown in fig. (c).

When the cork screw is moved in the direction of current then the direction in which its handle is turned gives us the direction of the magnetic field. In short we can say that **when current flows vertically upward then direction of magnetic field produced is anticlockwise and when current flows vertically downward then direction of magnetic field is clockwise.**



Fig. (c) Cork screw

Case 2. When Current is Circular, Magnetic Field is Straight.

When the current flows in a circular wire (coil), the magnetic field produced has straight lines of force near the centre of the coil, as shown in Fig. The parallel lines are lines in a plane perpendicular to the plane of the coil. Their direction is marked by the arrows.

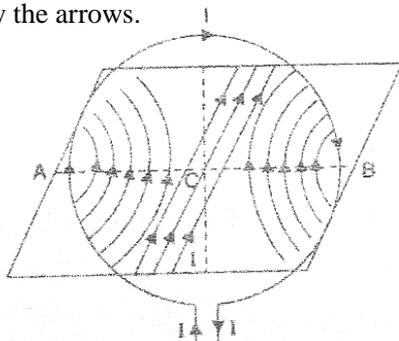
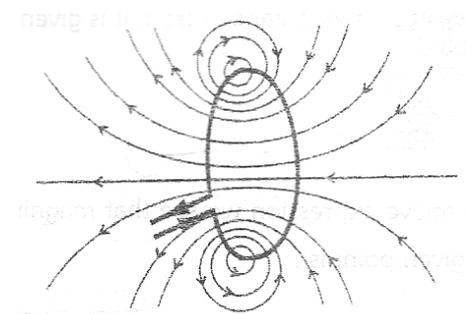


Fig. Current circular, magnetic field straight



Straight lines at the middle of the coil are due to the fact that each small segment of the circular coil is surrounded by the magnetic lines of force. At the centre of the coil, all lines of force add to each other resulting in the increase in strength.

It is found that magnitude of the magnetic field (B) at the centre of a circular coil carrying currents is directly proportional to amount of current flowing through the wire (I), inversely proportional to the radius of the coil (r) and directly proportional to the number of turns in the coil.

Mathematically,

$$B = \frac{\mu_0 n I}{2r} \quad \text{Here, } n \text{ is number of turns of the coil.}$$

MAGNETIC FIELD DUE TO CURRENT IN A SOLENOID

A coil of many turns of wire wrapped in the shape of a cylinder is called a solenoid i.e., a solenoid is a long cylindrical coil wound over a hollow cylinder (non conducting). It is shown in Fig.(a).

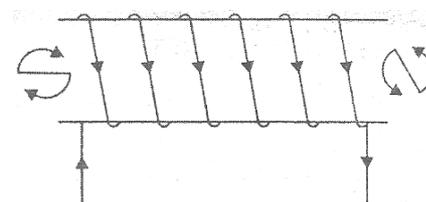


fig. (a) Solenoid carrying a current and polarity of its face

A solenoid differs from a circular coil in that the length of the solenoid is much greater than its diameter.

A solenoid behaves as if a large number of coils have been put one behind the other on the same axis over a length i.e., magnetic field produced by a current carrying solenoid is similar to the magnetic field produced by a bar magnet. Current in solenoid produces magnetic field in each turn, which becomes **additive**.

Polarity of magnetic field exists only at the ends of the solenoid, as shown in Fig.(a).

One end of the coil acts as a north pole while the other end acts like a south pole.

Inside the solenoid the magnetic field is uniform (same at all points). It is represented by parallel and straight field lines. Magnetic field outside the solenoid is non-uniform.

Magnetic lines of force inside the solenoid are from South Pole to North Pole, while outside the solenoid these lines are from North Pole to South Pole.

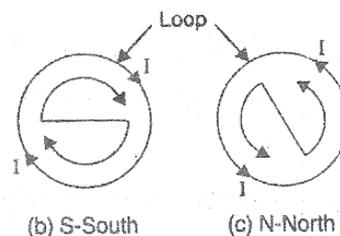


Fig.(b & c) Direction of current in loop.

RULE FOR POLARITY AT THE ENDS: If at any end, the current in the coil (or loop) is clockwise, the face of the coil towards the observer behaves as a south pole. [Fig. (b)]

If at any end, the current in the coil is anticlockwise, the face of the coil towards the observer behaves as a north pole [Fig. (c)]

Fig. (d) shows the magnetic field around a current carrying solenoid.

- (i) Number of turns per unit length (n) of the solenoid and $B \propto n$
 - (ii) Strength of the current (I) in the solenoid and $B \propto I$
 - (iii) Nature (relative permeability, μ_r) of the core material of the solenoid and $B \propto \mu_r$
- or $B \propto \mu_r nI$ or $B = \mu_0 \mu_r nI$

where μ_0 represents permeability of free space.

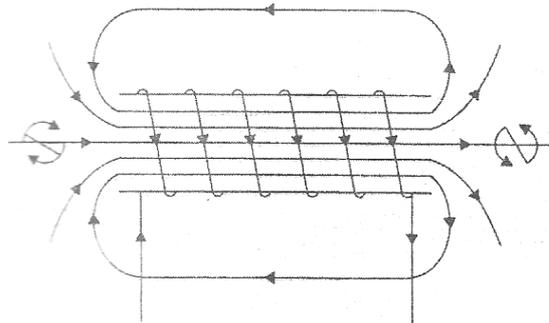


Fig. (d) Magnetic field around a solenoid: the-field is straight inside it.

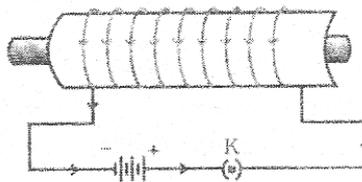
Note: Permeability is a magnetic property a material related to magnetism.

Que. How are the fields of a current-carrying solenoid and coil different?

Sol. The field inside a current carrying solenoid is quite uniform for the most part. It only decreases near the ends. The field of a current carrying coil is not uniform. It changes with distance from the centre.

ELECTROMAGNET

Strong magnetic field which can be produced due to the flow of current can be used to magnetise a piece of magnetic material like steel rod, soft iron etc, when placed inside the coil. Magnet so produced is called electromagnet. Thus we can say that an electromagnet consists of many turns of insulated copper wire wound over a soft iron core or horse-shoe-magnet.



Strength of the electromagnet depends on:

- (i) **Number of turns in the coil:** If number of turns in the coil are more, electromagnet will be strong.
- (ii) **Current flowing in the coil:** Strength of electromagnet is directly proportional to the current flowing through the coil, and

(iii) **Length of air gap between the poles:** Strength of the electromagnet is inversely proportional to the distance between its poles.

Electromagnets are used to extract bullets from the body, to lift big machines and in electronic devices. Large values of μ , n and I can produce very strong magnetic field inside the solenoid.

Electromagnets are better than permanent magnets as their strength can be controlled by changing the number of turns in the coil or by changing the current flowing through the coil.

Permanent magnets are usually made of some alloys of steel of because permanent magnets made from alloys are very strong than those made from ordinary steel.

Difference between an Electromagnet and a Permanent magnet

| | Electromagnet | Permanent magnet |
|---|--|---|
| 1 | It behaves as a magnet as long as electric current passes through the solenoid surrounding it. It is demagnetised when electric current stops passing through the solenoid. Thus, electromagnet is a temporary magnet. | It cannot be demagnetised easily |
| 2 | Electromagnet gives a strong magnetic field and the strength of the magnetic field produced by this electromagnet can be increased or decreased by increasing or decreasing electric current through the solenoid. | Magnetic field of a permanent magnet is weak. The strength of magnetic field of the permanent magnet cannot be changed. |
| 3 | The polarity (i.e. North and South poles) of an electromagnet can be reversed by reversing the direction of electric current through the solenoid. | The polarity of a permanent magnet cannot be reversed. |

DO YOU KNOW

- ▶▶ Hard steel, alnico (an alloy of aluminum, nickel, cobalt, iron and nipermag (an alloy of aluminum, iron and titanium) are used to make permanent magnets.
- ▶▶ Soft iron is used to make electromagnets.
- ▶▶ A steel rod can be made a permanent magnet if it is placed inside a solenoid carrying direct current.
- ▶▶ Permanent magnets are used in loudspeakers, galvanometers, voltmeters, ammeters and speedometers.
- ▶▶ Permanent magnet can be demagnetized by heating it.

FORCE ON A CURRENT CARRYING CONDUCTOR PLACED IN A MAGNETIC FIELD AND FLEMING'S LEFT HAND RULE

A current carrying conductor produces a magnetic field around it. When it is placed in a magnetic field, the two magnetic fields interact with each other and a net force acts on the conductor.

If the conductor of length ℓ carrying current I is lying inside a magnetic field of intensity B and is making an angle θ with it, then force acting on the conductor is given by

$$F = I\ell B \sin \theta$$

If the conductor is lying perpendicular to the magnetic field, then

$\theta = 90^\circ$ [$\sin \theta = 1$] and the force becomes $F = I \ell B$.

This force acts in a direction which is perpendicular to the plane containing the conductor and the magnetic field (Fig.) and is maximum.

If the conductor is lying parallel to the magnetic field, then $\theta = 0^\circ$ ($\sin \theta = 0$) and the force becomes zero and is minimum.

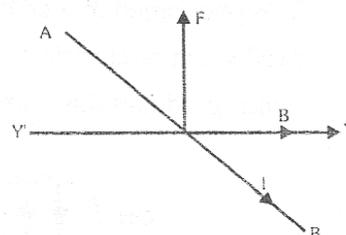


Fig. Force on a conductor

FLEMING'S LEFT HAND RULE

Direction of the force action on a current carrying conductor when placed in a magnetic field is given by Fleming's left hand rule, which states that:

If the forefinger, second finger and thumb of the left hand are stretched at right angles to each other, with the forefinger in the direction of the field and the second finger in the direction of the current then the thumb indicates the direction of the force.

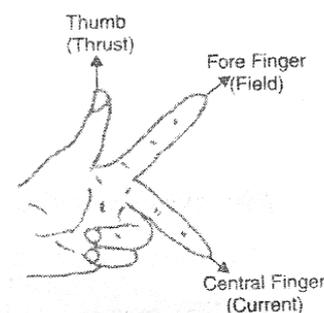


Fig. Fleming's left hand rule

FACTORS ON WHICH THE FORCE ACTING ON THE CURRENT CARRYING CONDUCTOR DEPENDS

The force acting on a current carrying conductor is placed in the magnetic field depends upon:

- (i) **The strength of the magnetic field:** If the conductor is placed in a strong magnetic field, it experiences a large force. That is, $F \propto B$ (strength of magnetic field)
- (ii) **The strength of the electric current:** If large current flows through the conductor placed in the magnetic field, it experiences a large force. That $F \propto I$.
- (iii) **The length of the conductor:** A long conductor experiences a greater force than the short conductor, when placed in the magnetic field. That is, $F \propto \ell$.

That is $F \propto BI \ell$
 or $F = kBI \ell$
 If $k = 1$, $F = BI \ell$

then $B = \frac{F}{I\ell}$

If $I = 1$ amp. and $\ell = 1$ m then $B = F$

Thus, magnetic field strength (B) is defined as the force acting per unit current per unit length of a conductor placed perpendicular to the direction of the magnetic field.

SI unit of magnetic field strength is Tesla.

$$1\text{Tesla} = \frac{1\text{Newton}}{1\text{Ampere} \times 1\text{metre}} = 1\text{N A}^{-1}\text{m}^{-1}$$

ELECTROMAGNETIC INDUCTION

The phenomenon in which an electric current is induced in a circuit because of a changing magnetic field is called electromagnetic induction.

When a straight metallic wire is moved up and down in a magnetic field between the two poles of a horse shoe magnet then magnetic flux (number of magnetic lines of force) linked with the wire changes and an electric current is produced in the wire. A galvanometer connected across the two ends of the wire shows some deflection indicating that some current is produced. This current lasts only as long as the change in the flux continues.

This phenomenon is called electromagnetic induction. In short we can say that electromagnetic induction means production of electricity from magnetism. The electric current produced, is called induced current. The e.m.f. which produces this current is called induced e.m.f.

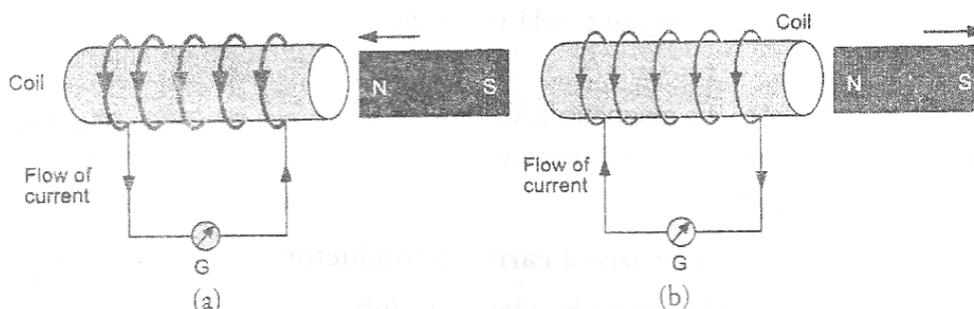


Fig. – electromagnetic induction

FACTORS OF WHICH INDUCED CURRENT DEPENDS

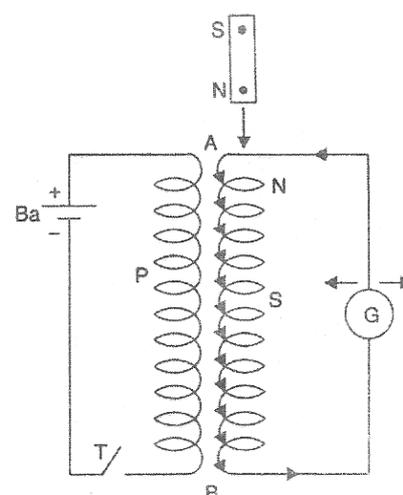
The value of induced current depends upon:

- (i) **The number of turns in the coil:** If coil has large number of turns, then large induced current is produced in the closed coil.
- (ii) **The strength of the magnet:** A strong magnet moved towards or away from the closed coil produced a large induced current.
- (iii) **The speed with which the magnet moves towards the coil:** If the magnet moves very quickly, then large induced current is produced in the closed coil.

FARADAY'S DISCOVERY OF ELECTROMAGNETIC INDUCTION

Michael Faraday in 1831, discovered phenomenon of electromagnetic induction. His experimental set up is shown in fig.

When North Pole of a magnet was held above end A of secondary coil S, no deflection was seen in galvanometer G. As the pole was moved towards the coil, galvanometer showed some deflection to the right. When magnet was left inside coil, galvanometer deflection becomes zero. When he took the magnet out of the coil, deflection in the galvanometer to the left side was observed. Hence current flow only when magnet was in motion and not when it was at rest near the coil or inside the coil.



Faraday performed a similar experiment by putting a primary coil P near coil AB. He completed primary circuit with a battery Ba and tapping key T.

So long as key was open, no deflection was seen in the galvanometer G. As the key was pressed and primary circuit was closed, galvanometer showed some deflection to the right. Deflection became zero when key was kept pressed. When key was left to open, deflection in the galvanometer to the left side was observed.

The closing and opening of circuit changed the current in primary coil, which produced changing magnetic flux in the primary. This changing magnetic flux become linked with secondary and produces induced current (just as done by moving magnet), in the secondary.

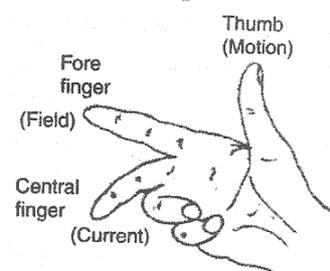


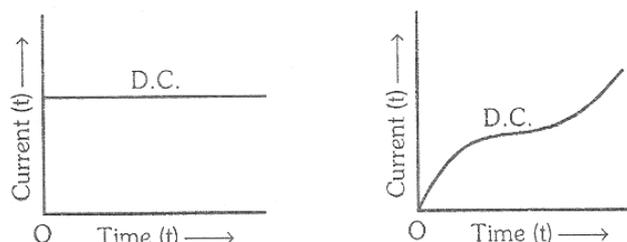
Fig. Fleming's Right Hand Rule

Direction of the induced current is given by **Fleming Right Hand rule which states that** Stretch the thumb, the fore finger and central finger of right hand in such a way that they are mutually perpendicular to each other. Then, if fore finger represents direction of Field and thumb represents direction of Motion of the conductor, then Central finger will represent the direction of induced Current (fig.).

DIRECT AND ALTERNATING CURRENT

DIRECT CURRENT (D.C.): A current which has a constant magnitude and same direction, is called a direct current

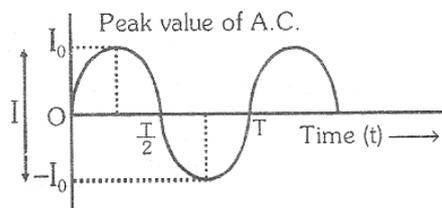
Current due to a cell or a battery is a direct current.



ALTERNATING CURRENT (A.C.): A current which changes in magnitude and direction at regular intervals of time is called an alternating current.

The frequency of household supply of a.c. in India is 50 Hz. This means, a.c. completes 50 cycles in one second. Thus, a.c. changes direction after every $\frac{1}{100}$ second. In other words, a.c. used in India changes direction 100 times in one second.

Current changes direction after each rotation of the coil.



Frequency: Frequency of A.C. is the number of cycles per second completed by the current. One cycle is completed when the A.C. rises from zero to maximum positive then back to zero and then the maximum negative and zero again.

ADVANTAGES AND DISADVANTAGES OF A.C. OVER D.C.

A.C. has following merits (advantages) over D.C.:

1. A.C. can be transmitted over long distances without much loss of energy.
2. A.C. can be produced easily and cheaply than D.C.
3. A.C. voltage can be transformed to any desired value with the help of a transformer.
4. Transmission of A.C. at “high-voltage” and “low-current” reduces line losses.
5. A.C. motors or other A.C. appliances are easier to operate.
6. A.C. can easily be converted to D.C. when required.

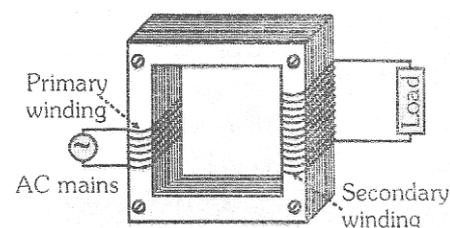
A.C. has following demerits (disadvantages) over D.C.:

1. A.C. attracts a person who touches its line whereas D.C. gives a repelling shock.
2. A.C. gives a huge and sudden shock which becomes fatal.
3. A.C. is conducted over the surface of a conductor (skin effect). It increases effective resistance of the conductor.
4. Commercial generators do not produce pure A.C.
5. In certain applications like electroplating, battery charging etc. only D.C. is required.
6. A.C. is more dangerous than D.C.

DO YOU KNOW

Transformer is a device which changes small a.c. potential difference to a large a.c. potential difference. Transformer consists of two coils of wire wound around a core of soft iron. One coil is known as primary coil and the other is known as secondary coil as shown in figure.

Transformer is used to transmit a.c. to distant places through conductors (called transmission lines) without much loss of electric energy or power.



DOMESTIC ELECTRIC CIRCUITS

SUPPLY FROM POWER STATIONS: Electricity is generated at power station. In our homes, we receive the supply of electric power either supplied through overhead poles or underground cables using two thick aluminium wires.

MAIN BOARD: It is provided outside the building under a covered place (veranda or porch or balcony). It contains the meter (energy-meter) and the main switch. (Fig.)

From the street electric pole, a thick rubber insulated cord reaches the main board. It contains two thick copper or aluminium wires, one covered with red and the other covered with black (or brown) plastic covering.

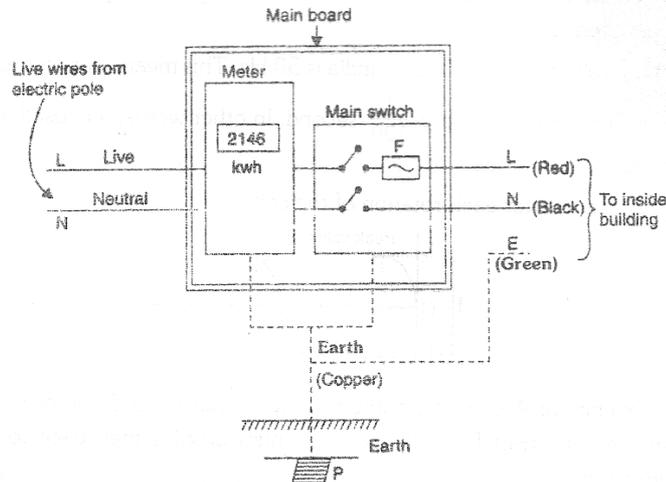


Fig. Main board outside the building

They form the lifeline wire (L) and neutral line wire (N) respectively.

Live line wire has a potential or 220 V whereas the neutral wire has zero potential (with respect to the earth). They enter the main board and are connected to the meter.

Wiring ahead is provided by the house owner himself. These wires are also red black plastic covered. From the meter the wires enter the main switch. In the main switch, a fuse F is provided in the path of live wire.

From outside the main switch, the wires become free to be used inside the building as required.

A third wire is a thick bare wire of copper. Called earth wire E. It is connected to an earth connection which consists of a thick copper plate P buried deep inside the moist earth.

INSIDE THE BUILDING: It is a well known fact that inside the house, connections to all the devices are made in parallel, each having independent switch and fuse (if necessary). Thus, whenever some fault occurs in circuit of one particular device in one room, devices in other rooms do not suffer.

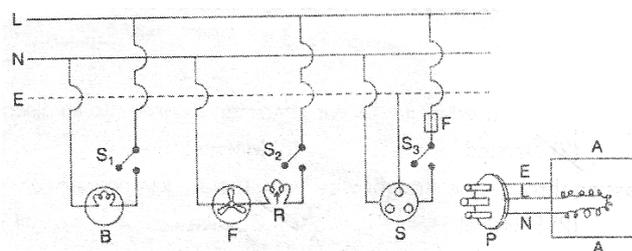


Fig. Circuit inside the building.

As shown in Fig. , connection to low power devices like bulb B and fan F are made with lines N and L only, putting switch in line L. For devices of more power and with whom the body remains in contact (like electric press or refrigerator), we use connections through a 3 pin plug socket (shoe) system.

A three pin plug P and three pin socket S are shown in Fig.. The three points of the socket are connected to the three lines as shown in the diagram. A fuse F is also introduced to avoid damage to the appliance.

The three pin plug uses a three wire cord which has three plastic wires inside a single rubber insulating cover. The wires are colored: red, black (or brown) and green respectively to serve as an extension of live, neutral and earth wires

for the appliance. The three wires are connected to there hole in the socket as shown in Fig. When the plug is inserted in the socket, proper lines get connected to the appliance.

ELECTRIC FUSE: An electric fuse is a safety device used to save the electrical appliances like electric bulbs, electric tubes, T.V. etc. from burning when large current flows in the circuit. Electric fuse is a wire made of copper or aluminum or tin-lead alloy. The melting point of the material of which the electric fuse wire is made should be low.

Suppose a fuse is not connected in the path of a live wire of the circuit. In such case, the circuit may be over heated if the current in the circuit exceeds the safe limit. There is a change of short circuiting of the circuit which causes the fire. So to avoid short circuiting of the circuit, a fuse must be but in the path of the circuit.

FUNCTION OF EARTH WIRE: Due to the long use, some covered wires inside the appliance may become bare and may make contact with metallic body of the appliance. In such a case the appliance gives a shock if not earthed. The earth wire keeps the potential of the of appliance zero and shock is avoided

USE OF SWITCH: All electrical appliances are provided with separate switches. All switches are connected with live wire as well as with neutral wire. When we switch off an appliance, then it gets disconnected from the live wire. Now if one touches the metallic body of the appliance there is no danger of electric shock. But, if connections to the switch are in such a way that on switching off the appliance, neutral wire gets disconnected but not live wire, then is danger of electric shock.

SHORT CIRCUIT



Fig. (a) normal electric circuit (b) Short circuit

When the live wire and the neutral wire come into direct contact. This occurs when the insulation of wires is damaged or there is a fault in the appliance. In such a situation, the current in the circuit abruptly increases. This is called short-circuiting. When short circuiting occurs, the resistance of the circuit becomes very small and hence huge amount of current flows through it. Large amount of current in the circuit produces large amount of heat which raises the temperature of circuit to very high value. As a result of this, the circuit catches fire.

OVERLOADING: means flow of large amount of current in the circuit beyond the permissible value of current. It occurs when many electrical appliances of high power rating like geyser, heater, refrigerator, motor etc. are connected in a single socket or in a single circuit. High current flowing in the circuit due to overloading causes fire.

EXERCISE # 1

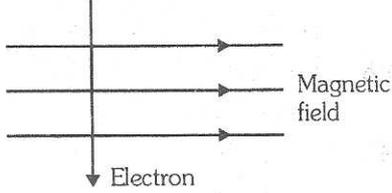
(FOR SCHOOL / BOARD EXAMS)

OBJECTIVE TYPE QUESTIONS

Choose the Correct One

1. The fact that magnetic field is produced around a wire carrying, was discovered by
 (1) Faraday (2) Oersted (3) Maxwell (4) Joule.
2. When the current is passing through the straight wire then, the associated magnetic field is
 (1) Straight (2) Elliptical (3) Circular (4) Parabolic.
3. When current is circular, the associated magnetic field is
 (1) Straight (2) Elliptical (3) Circular (4) Paralytic
4. When current flows clockwise in a loop, the polarity of its face is
 (1) East (2) South (3) West (4) North
5. When current flows anticlockwise in a loop the magnetic polarity of the face is
 (1) East (2) South (3) West (4) North
6. For a solenoid carrying a current I and having n turns per unit length, wrapped on a core of permeability μ , the correct expression for magnetic field intensity (2) is
 (1) $B = \frac{\mu_0}{\mu} nI$ (2) $B = \frac{\mu_0 \mu I}{\mu}$ (3) $B = \mu_0 \mu nI$ (4) $B = \frac{\mu_0 \mu n}{I}$
7. Magnets having temporary magnetism are called
 (1) Electromagnets (2) Bar magnets (3) Circular magnets (4) Horse-shoe magnets.
8. Direction of force acting on a current carrying conductor kept in magnetic field is given by
 (1) Fleming's right hand rule (2) Fleming's left hand rule
 (3) Lenz's rule (4) Faraday's rule
9. The electric device which works on the phenomenon of force on a current carrying conductor in a magnetic field is
 (1) Generator (2) Accelerator (3) Motor (4) Transformer.
11. Electromagnetic induction was discovered by
 (1) Oersted (2) Maxwell (3) Thomson (4) Faraday.
11. Direction of induced current produced by motion of a conductor in a magnetic field is given by
 (1) Fleming's right hand rule (2) Fleming's left hand rule
 (3) Lenz's rule (4) Faraday's rule

12. In domestic electric circuits, fuse must be placed in series with
(1) Earth wire (2) Neutral wire
(3) Live wire (4) Any or the three wires.
13. Elective and main switch is contained in a main board fitted usually
(1) At street electric pole (2) At main gate of building
(3) In verandah or parch (4) In bed or study room.
14. High powered electrical appliances are earthed to
(1) Avoid shock (2) Avoid wastage
(3) Make the appliance look beautiful (4) Reduce the bill.
15. In a three pin socket (shoe) the bigger hole is connected to
(1) Any wire (2) Live wire (3) Neutral wire (4) Earth wire
16. Due to overloading, the current in circuit becomes
(1) Less (2) More (3) Zero (4) Not definite.
17. Coming of live and neutral wire in direct contact causes
(1) Short-circuiting (2) Over-loading (3) No damage (4) Unknown effect.
18. Melting point of material of a fuse wire must be
(1) Moderate (2) High (3) Low (4) Infinite.
19. A high powered electric appliance has used inferior wires and is not earthed. It is source of
(1) No concern (2) Less concern (3) Moderate concern (4) Hazard.
20. 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 scented on the wire.
21. 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 by relative motion between a magnet and the coil
(4) The process of rotating a coil of an electric motor.
22. The device used for producing electric current is called a
(1) Generator (2) Galvanometer (3) Ammeter (4) Motor

23. At the time of short-circuit, the current in the circuit
 (1) Reduces substantially (2) Does not change
 (3) Increases heavily (4) Vary continuously
24. An electron enters a magnetic field at right angles to it as shown in figure. The direction of force action on the electron will be
 (1) To the right
 (2) To the left
 (3) Out of the page
 (4) Into the page
- 
25. Which of the following property of a proton can change while it moves freely in a magnetic field? (The may be more than one correct answers)
 (1) Mass (2) Speed (3) Velocity (4) Momentum.
26. A positively-charged particle (alpha particle) projected towards west is deflected towards north by a magnetic filed. The direction of magnetic field is
 (1) Towards south (2) Towards east (3) Downward (4) Upward.
27. 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.
28. 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.
29. A magnetic field exerts no force on:
 (1) An electric charge moving perpendicular to its direction (2) an unmagnified iron bar
 (3) a stationary electric charge (4) a magnet
30. Which of the following instruments works by electromagnetic induction?
 (1) telephone receiver (2) simple motor
 (3) dynamo (4) moving coil galvanometer.
31. The use of fuses in electric power-lines is:
 (1) to keep main voltage constant
 (2) to open the line permanently when there is an overload
 (3) just to show an indication when there is an overload
 (4) as a switch to use in an emergency

32. When the main switch of the house circuit is put off, it disconnects the:
(1) live wire (2) neutral wire (3) earth wire (4) live and neutral wires
33. When a fuse is rated at 8 A, it means:
(1) it will not work if current is less than 8 A (2) it has a resistance of 8 ohm
(3) it will work only if current is 8 A (4) it will burn if current exceeds 8 A.
34. According to international Convention of colour coding of wires used in household electrical circuits:
(1) live is red, neutral is black and earth is green
(2) live is red, neutral is green and earth is black
(3) live is brown, neutral is blue and earth is black
(4) live is brown, neutral is light blue and earth is green
35. The magnetic field lines inside a current carrying solenoid are:
(1) along the axis and parallel to each other
(2) perpendicular to the axis and equidistant from each other
(3) circular and they do not intersect each other
(4) circular at the ends but they are parallel to the axis inside the solenoid
36. Potential difference between a live wire and the neutral wire is:
(1) 150 V (2) 210 V (3) 200 V (4) 220 V
37. Which of the following statements is incorrect regarding magnetic field lines:
(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 strength
(4) Relative strength of magnetic field is shown by the degree of closeness of the field lines
38. Magnetic field lines determine:
(1) The shape of the magnetic field
(2) Only the direction of the magnetic field
(3) Only the relative strength of the magnetic field
(4) Both the direction and the relative strength of the magnetic field
39. The magnetic field near a long straight wire is described by:
(1) Straight field lines parallel to the wire (2) Straight field lines perpendicular to the wire
(3) Concentric circles centered on the wire (4) Radial field lines starting from the wire

40. The phenomenon of electromagnetic induction is:
 (1) The process of charging a sphere.
 (2) The process of producing magnetic field in a coil
 (3) The process of producing induced current in a coil whenever there is a relative motion between the coil and the magnet
 (4) The process of producing cooling effect.
41. Potential difference between a live wire and the neutral wire is:
 (1) 200 volt (2) 150 volt (3) 210 volt (4) 220 volt
42. A rectangular coil of copper wires is rotated in a magnetic field. The direction of the induced current changes once in each:
 (1) One revolution (2) One-fourth revolution (3) Half revolution (4) Two revolutions
43. Magnetic field inside a long solenoid carrying current is:
 (1) Same at all points
 (2) Minimum in the middle
 (3) More at the ends than at the centre
 (4) Found to increase from one end to the other.
44. At the time of short circuit, the current in the circuit:
 (1) Vary continuously (2) Reduces considerably (3) Increases heavily (4) does not change.
45. The frequency of direct current is:
 (1) Zero (2) 50 Hz (3) 60 Hz (4) 100 Hz
46. The frequency of household supply of a.c. in India is:
 (1) Zero (2) 50 Hz (3) 60 Hz (4) 100 Hz
47. The most important safety device method used for protecting electrical appliances from short circuiting or overloading is:
 (1) Earthing (2) Use of stabilizers (3) Use of electric meter (4) Use of fuse
48. Current flowing in conductor A is 2A and current flowing in conductor B is 4A. The ratio of magnetic field produced around conductor A to the magnetic field produced around conductor B at a distance 10 cm from both the conductors is:
 (1) 2: 1 (2) 1: 2 (3) 4: 1 (4) $\sqrt{2} : 1$
49. Current flowing in conductors A and B is same, what is the ratio of the magnetic field produced around the conductor A at a distance of 5 cm from the conductor to the magnetic field produced around the conductor B at a distance of 2 cm from this conductor is
 (1) 0.04 (2) 0.4 (3) 4.0 (4) 10

- 50.** Same amount of current flows in the same direction. Long the two parallel conductors separated by a small distance:
 (1) Both conductors attract each other
 (2) Both conductors repel each other
 (3) Conductors neither attract each other nor repel each other
 (4) Both conductors rotates about their axis
- 51.** When an electric current flows through a long solenoid, magnetic field is set up in and around the solenoid:
 (1) Magnetic field inside the solenoid is non-uniform and weak
 (2) Magnetic field outside the solenoid is uniform and strong
 (3) Magnetic field inside the solenoid increases as we move towards the ends of the solenoid
 (4) Magnetic field of solenoid resembles the magnetic field of the bar magnet.
- 52.** Magnetic field produced at the centre of a current carrying circular wire is:
 (1) Directly proportional to the square of the radius of the circular wire
 (2) Directly proportional to the radius of the circular wire
 (3) Inversely proportional to the square of the radius of the circular wire
 (4) Inversely proportional to the radius of the circular wire.
- 53.** The direction of the magnetic field at a pint P above the current carrying wire is
 (1) Down the page (2) Up the page (3) Into the page (4) Out of the page
- 54.** Which of the following properties of a proton can change while t moves freely in a magnetic field?
 (1) Mass (2) Speed (3) Velocity (4) Momentum
- 55.** A positively charged particle says an alpha particle projected towards west is deflected towards north by a magnetic field. The direction of the magnetic field is:
 (1) Upward (2) Downward (3) Towards south (4) Towards east
- 56.** Magnitude of magnetic field intensity at a point around a current carrying conductor is B. If the strength of current in the conductor becomes double, then the magnitude of magnetic field intensity at the point around the conductor is:
 (1) $\frac{B}{2}$ (2) B (3) $\frac{B}{4}$ (4) 2B
- 57.** Two parallel conductor carrying current in the same directions
 (1) Repel each other
 (2) Attract each other
 (3) Sometimes attract and sometimes repel each other
 (4) None of these

58. Two parallel conductor carrying current in the opposite directions
 (1) Repel each other
 (2) Attract each other
 (3) Sometimes attract and sometimes repel each other
 (4) None of these
59. Force acting on a stationary charge Q in the magnetic field B is:
 (1) BQv (2) BQ/v (3) Bv/Q (4) Zero
60. If the plug of the key is taken out (i.e. the circuit is made open) and magnetic field lines are drawn over the horizontal plane white sheet of paper, the lines are:
 (1) Concentric circles (2) Elliptical in shape
 (3) Straight lines parallel to each other (4) Parabolic in shape
61. When current passes through a long straight solenoid, N and S poles are created at the two ends of the solenoid. Which of the following statements is incorrect?
 (1) The field lines inside the solenoid are in the form of straight lines indicating that magnetic field is same at all the points inside the solenoid.
 (2) The pattern of the magnetic field lines associated with the solenoid is different from the pattern of the magnetic field lines around a bar magnet.
 (3) N-and S-poles exchange positions when the direction of the current through the solenoid is reversed.
 (4) Magnetic field produced inside the solenoid can be used to magnetize a bar of magnetic material like soft iron, when placed inside the solenoid.

In these type of Questions, two statements are given. Choose the correct option by following directions given below: (Q. 80 to 83)

- (1) **Statement I is correct and Statement II is correct explanation of the statement I.**
 (2) **Statement I is correct but Statement II is not the correct explanation of the statement I.**
 (3) **Statement I is true but statement II is not true.**
 (4) **Statement I is not true but statement II is true.**

62. **Statement I:** A soft iron bar placed inside a solenoid carrying current is magnetized.
Statement II: Magnetic field inside a long solenoid carrying current is non-uniform.
 (1) A (2) B (3) C (4) D
63. **Statement I:** The strength of magnetic field of a permanent magnet decreases with the increase in temperature.
Statement II: A permanent magnet can be demagnetized by heating it.
 (1) A (2) B (3) C (4) D
64. **Statement I:** A charged particle moving parallel to the direction of magnetic field experiences a force.
 (1) A (2) B (3) C (4) D

72. Current can be made to flow through a coil without connecting the coil with a battery. Which of the following procedures would be most suited to test this fact?
- (1) Connect a galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is placed near the one end of the coil
 - (2) Connect a galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is placed inside the coil.
 - (3) Connect the galvanometer across the ends of a coil and observe if galvanometer shows a deflection, when a bar magnet is moved towards or away from the coil and along the axis of the coil.
 - (4) Connect the galvanometer across the ends of the coil and observe if galvanometer shows a deflection, when a bar magnet is moved at right to the axis of the coil.
73. Two coil A and B placed close to each other. If current in the coil A is changed, some current will be induced in the coil B. This is because of electromagnetic induction. In this statement
- (1) Inference is correct but reasoning is not correct
 - (2) Inference is incorrect but reason is correct
 - (3) Inference as well as reasoning are correct
 - (4) Neither inference nor reasoning is correct.

ANSWER – KEY

| | | | | | | | | | | | | | | | |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Que. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Ans. | 2 | 3 | 1 | 2 | 4 | 3 | 1 | 2 | 3 | 4 | 1 | 3 | 3 | 1 | 4 |
| Que. | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Ans. | 2 | 1 | 3 | 4 | 4 | 3 | 1 | 3 | 4 | 3 | 4 | 3 | 4 | 3 | 3 |
| Que. | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| Ans. | 2 | 4 | 4 | 4 | 1 | 4 | 3 | 4 | 3 | 3 | 4 | 3 | 1 | 3 | 1 |
| Que. | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| Ans. | 2 | 4 | 2 | 2 | 1 | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 1 | 4 | 3 |
| Que. | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | | |
| Ans. | 2 | 3 | 1 | 4 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | | |

EXERCISE # 2

(FOR SCHOOL / BOARD EXAMS)

FILL IN THE BLANKS

1. The phenomenon of production of magnetic field around a current carrying conductor is calledeffect of current.
2. The rule which relates direction of deflection of magnetic needle with direction of field is calledrule
3. When a wire is wrapped into many close turns over a cylindrical core, it forms a
4. To have north polarity at a face, the current in loop must flow indirection.
5. To have south polarity at a face, the current in loop must flow indirection.
6. In electromagnets, magnetism is
7. In electromagnetic induction, motion of a.....in a fixed coil produces electric current.
8. An electric current having a constant magnitude and direction, is called acurrent.
9. An electric current having a changing magnitude and direction, is called ancurrent.
10. In domestic electric circuit
 - (i) Fuse is connected inwire
 - (ii) The colour of live wire is.....
 - (iii) The colour of neutral wire is
 - (iv) The colour of earth wire is
 - (v) Shock is avoided bythe appliance.
11. For earthing of an appliance we use.....pin plug and socket (shoe).
12. A large current flows in the circuit due toand
13. To avoid damage due to large current we must use a.....

WRITE TRUE OR FALSE IN THE FOLLOWING STATEMENTS

1. When some electric current flows through a wire, magnetic field is produced around the wire.
2. Electric current in a straight wire produces straight magnetic field.
3. A wire wrapped into many close turns over a cylindrical core forms a solenoid.
4. A coil with large number of turns forms a solenoid.
5. Direct current has a constant magnitude and direction.
6. Alternating current has a changing magnitude with no change in direction.
7. Fuse wire saves the electrical appliances from being damaged by excess current.
8. Fuse wire is used in parallel with the appliance.

9. Earthing the high powered electrical appliances saves them from electric shocks.
10. Earth wire has red colour.
11. The field at the centre of a long circular coil carrying current will be parallel straight lines.
12. A wire with a green insulation is usually the live wire.
13. Like magnetic poles attract each other and unlike magnetic poles repel each other.
14. Magnetic field lines determine only the direction of magnetic field but not the relative strength of the magnetic field.
15. Magnetic field lines are crowded in a region of strong magnetic field.
16. Two magnetic field lines can cross each other.
17. Magnetic field lines around a current carrying wires are concentric circles with their centres on the wire.
18. Two parallel wires carrying current in the same direction repel each other.
19. Two parallel wires carrying current in opposite direction attract each other.
20. The field at the centre of long circular coil carrying current will be parallel straight lines.
21. The magnetic field inside a current carrying solenoid is uniform magnetic field.
22. Direction of force experienced by a current carrying wire placed perpendicular to the magnetic field is determines by Fleming's left hand rule.
23. A static charge placed in a magnetic field experiences a force.
24. Potential difference is set up across the ends of a wire when it is placed in the uniform magnetic field.
25. The melting point of the material of which electric fuse wire is made should be low.
26. During short circuiting, the resistance of the circuit is very small.
27. A wire with a black colour is the earth wire of an electric supply.
28. A wire with a green colour is the live wire of an electric supply.

VERY SHORT ANSWER TYPE QUESTION

1. What is meant by magnetic field?
2. How is the direction of magnetic field at a point determined?
3. Define a magnetic field line
4. At what place of the magnet are the magnetic field lines denser?
5. How is the strength of the magnetic field around a wire related to the strength of the electric current flowing in the wire?
6. How can it be shown that magnetic field exists around a wire through which direct current is passing?
7. An alternating current has frequency of 50 Hz. How many times does it change its direction in one second?

OR

How many times does AC used in India change direction in one second?

8. What is the nature of magnetic field lines around a current carrying wire?
9. State the rule used to determine the direction of magnetic field produced around a straight conductor carrying current.
10. Name the rule used to determine the direction of magnetic field due to a current carrying circular loop of a wire.
11. Write an expression for the force acting on a conductor of length (ℓ) carrying current (I) and placed perpendicular to the magnetic field (B).
12. State the rule to determine the direction of a force experienced by a current-carrying straight conductor placed in a magnetic field which is perpendicular.
13. What is a solenoid?
14. Write one application of magnetic field of current carrying solenoid.
15. Define electromagnetic induction.
16. When is the force experienced by a current-carrying conductor placed in a magnetic field largest?
17. What is the frequency of direct current (D.C)?
18. What is the meaning of the term “frequency” of an alternating current? What is its value in India?
19. What do you understand by the current rating of an electric fuse?
20. Name the material generally used to make electric fuse.
21. Why is an alternating current considered to be advantageous over direct current for long range transmission of electric energy?
22. State the rule of determines the direction of current induced in a coil due to its rotation in a magnetic field.
23. How is induced current in a secondary coil related to current in a primary coil?

ANSWER THE FOLLOWING QUESTIONS

1. Why does a compass needle get deflected when brought near a bar magnet?
2. Draw magnetic field lines around a bar magnet.
3. List the properties of magnetic lines of force.
4. Why don't two magnetic lines of force intersect each other?
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.
6. The magnetic field in a given region is uniform. Draw a diagram to represent it.
7. State Fleming's left-hand rule.
8. Explain different ways to induce current in a coil.
9. Name some sources of direct current.
10. Which sources produce alternating current?

11. An electric oven of 2 kW power rating is operated in a domestic electric circuit (220 V) that has a current rating of 5A. What result do you expect? Explain.
12. Name two safety measures commonly used in electric circuits and appliances.
13. What precaution should be taken to avoid the overloading of domestic electric circuits?
14. In household circuits, is a fuse wire connected in series or in parallel?
15. In which wire, (in A.C. circuit) , switch is introduced to operate the light?
16. List three sources of magnetic fields.
17. How does a solenoid behave like a magnet? Can you determine the north and south poles of current carrying solenoid with a help of bar magnet? Explain.
18. When is the force experienced by a current carrying conductor placed in a magnetic field is largest?
19. Think 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?
20. 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?
21. Two circular coils A and B 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.
22. 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.
23. What is the function of an earth wire? Why is it necessary to earth metallic appliances?
24. A current through a horizontal power line flows in east to west direction. What is the direction of magnetic field at a point directly below it and at a point directly above it?

ANSWER KEY
EXERCISE # 2

FILL IN THE BLANKS:

- | | | | | |
|----------------|-----------------------------------|-------------|------------------|------------|
| 1. Magnetic | 2. Right hand thumb rule | 3. Solenoid | 4. Anticlockwise | |
| 5. Clockwise | 6. Temporary | 7. Magnet | 8. Direct | |
| 9. Alternating | | | | |
| 10.(i) Series | (ii) Red | (iii) Black | (iv) Green | (v) Earthy |
| 11. Three | 12. Overloading, Short circuiting | 13. Fuse | | |

TRUE & FALSE

- | | | | | |
|-------|-------|-------|-------|-------|
| 1. T | 2. F | 3. T | 4. T | 5. T |
| 6. F | 7. T | 8. F | 9. T | 10. F |
| 11. T | 12. F | 13. F | 14. F | 15. T |
| 16. F | 17. T | 18. F | 19. F | 20. T |
| 21. T | 22. T | 23. F | 24. F | 25. T |
| 26. T | 27. F | 28. F | | |