UNIT 15

ELECTROMAGNETISM

After studying this unit, the students will be able to:

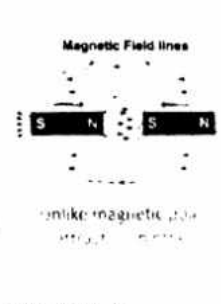
- **a.** Explain by describing an experiment that an electric current in a conductor produces a magnetic field around it.
- **b.** Describe that a force acts on a current-carrying conductor placed in a magnetic field as long as the conductor is not parallel to the magnetic field.
- **c.** State that a current-carrying coil in a magnetic field experiences a torque.
- **d.** Relate the turning effect on a coil to the action of a D.C. motor.
- **e.** Describe an experiment to show that a changing magnetic field can induce e.m.f. in a circuit.
- **f.** List factors affecting the magnitude of an induced e.m.f
- **g.** Explain that the direction of an induced e.m.f opposes the change causing it and relate this phenomenon to conservation of energy.
- **h.** Describe a simple form of A.C. generator.
- **i.** Describe mutual induction and state its units.
- **j.** Describe the purpose of transformers in A.C circuits.
- **k.** Identify that a transformer works on the principle of mutual induction between two coils.

Q.1 Demonstrate by an experiment that a magnetic field is produced around a straight current-carrying conductor?

Answer

Magnetic effects of a steady current

Ampere discovered that when a current pass through a conductor it produces magnetic field around it.



To demonstrate this, we take a straight conductor wire and pass it vertically through a card board as shown in fig. 15.1 (a). Now connect the two ends of the conductor wire with the terminals of the battery so that current flows through the circuit in the clockwise direction.

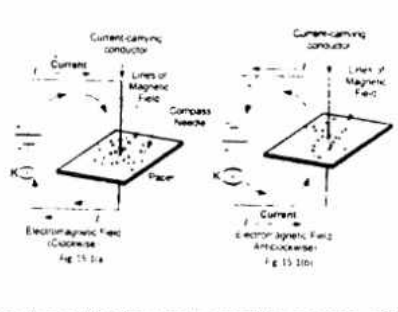
The lines of force of the magnetic field produced around the wire would be in the form of concentric circles.

If we put a compass needle at different points in the region of magnetic field, it will align along the direction of magnetic field.

Also, if we sprinkle some iron fillings on the card board around the wire, they will align themselves in concentric circles in the clockwise direction.

If we reverse the direction of the current by reversing the terminals of the battery, the compass needle also reverses its direction. '

Now the magnetic field lines will align in the anti-clock wise direction as shown in the figure 15.] (b).



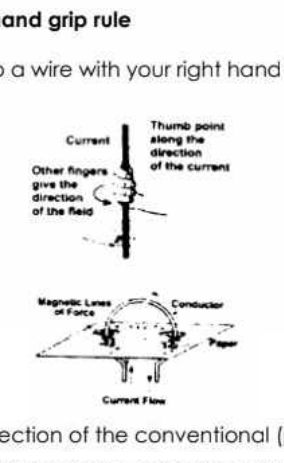
The magnetic field produced is stronger near the centre of the current carrying conductor and weaker farther away from it.

Q2 State and explain the rule by which the direction of the lines of force of the magnetic field around a current carrying conductor can be determined?

Answer

Right hand grip rule

"Grasp a wire with your right hand such that your thumb points in the direction of the conventional (positive) current. Then curling fingers of your hand will point in the direction of the magnetic field." It is called right hand grip rule.


Current
Thumb points along the direction of the current
Other fingers give the direction of the field
Magnetic Lines of Force
Conductor
Paper
Current Flow

Activity

Take a straight piece of wire and bend it into the form of a single loop. Now pass it through a card board having two holes. Connect the ends of loop to a battery so that a current start flowing through it as shown in fig. 15. 3. Now sprinkle some iron fillings on the card board. Note the pattern of the iron fillings that emerges on the card board.

Magnetic field of a solenoid

The long coil of wire consisting of many loops IS called a solenoid. The field from each loop in a solenoid adds to the fields of the other loops and creates greater total field strength as shown in the figure 15.4.

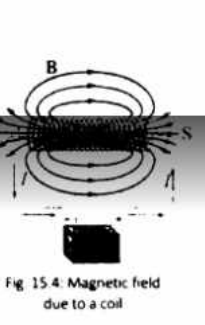


Fig. 15.4: Magnetic field due to a coil

Electric current in the coil of wire produces magnetic field which is similar to the magnetic field of a permanent magnet. When this current carrying coil is brought close to suspend bar magnet one end of the coil repels the north pole of the magnet. Thus, the current carrying coil has a north and a south pole and is itself magnet.

Electromagnet

The type of temporary, which is created when current flows through a coil, is called an electromagnet.

Direction of magnetic field

If we grip the coil with our right hand by curling our fingers in the direction of the conventional current, one thumb will indicate the north pole of the coil as shown in the figure15.5.

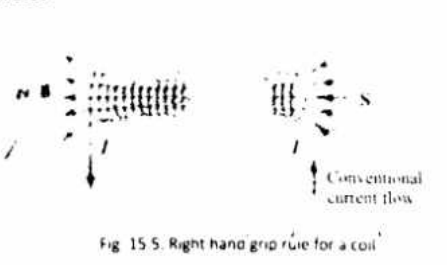


Fig. 15.5: Right hand grip rule for a coil

Q.3 When a straight current-carrying conductor is placed in a magnet field, it experiences a force. State the rule by which the direction of this force can be found out?

Answer

Since a magnetic field exerts force on a permanent magnet. It implies that current carrying wire should also experience a force when placed in a magnetic field.

The force on a wire in a magnetic field can be demonstrated using the arrangement shown in fig. 15.6. A battery produces current in a wire placed inside the magnetic field of a permanent magnet.

Current-Carrying wire produces its own magnetic field. Which interacts with the field of the magnet. As a result, a force is exerted on the wire.

Depending upon the direction of the current. the force on the wire either pushes or pulls it towards left as shown in fig. 15.6 (a) or towards right shown in fig. I5.6 (b).

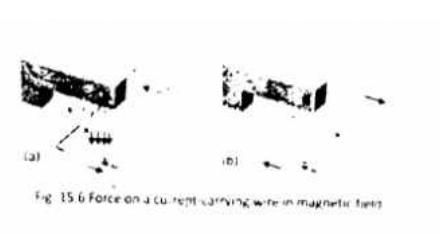


Fig. 15.6 Force on a current carrying wire in magnetic field

Michael Faraday discovered that the force on the wire is at right angles to both the direction of the magnetic field and the direction of current. The force Is increased if:

1) The current in the wire is increased.

2) Strength of magnetic field is increased.

3) The length of the wire inside the magnetic field is increased.

Determining the direction of force

The direction of the force on a current carrying wire in a magnetic field can be found by using Fleming's left-hand rule stated as:

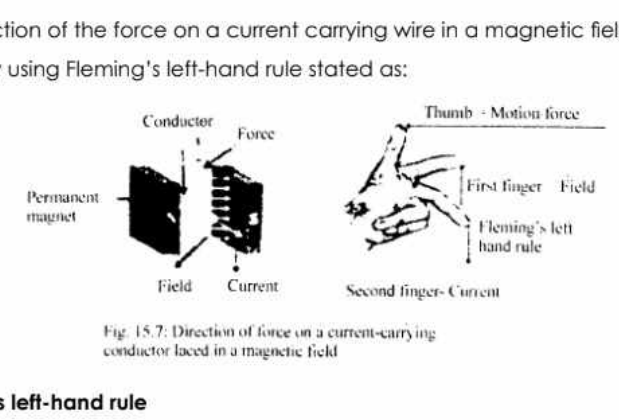


Fig. 15.7: Direction of force on a current-carrying conductor laced in a magnetic field

Fleming's left-hand rule

"Stretch the thumb, forefinger and the middle finger of the left hand mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field. the middle finger in the direction of the current, then the thumb would indicate the direction of the force acting on the conductor."

Q.4 State that a current-carrying coil in a magnetic field experiences a torque?

Answer

If instead of a straight conductor, we place a current—carrying loop inside the magnetic field. the loop will rotate due to the torque acting on the coil. This is also the working principal of electric motors.

Consider a rectangular coil of wire with sides PO and RS, lying perpendicular to the

field, placed between the two poles of a permanent magnet (fig. 15.8). Now if the ends

of the coil are connected with the positive and negative terminals of a battery, 3 current would start flowing through the coil. The current passing through the loop enters from one end of the loop and leaves from the other end.

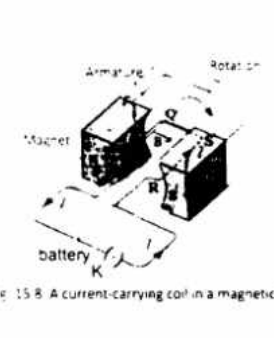


Fig. 15.8: A current-carrying coil in a magnetic field

Now apply Flemings left hand rule to each side of the coil. We can see that on PO side of the loop force acts upward, while on the RS side of the loop force acts downward it is because the direction of the current through the two sides of the loop facing the two poles is at right angles to the field but opposite to each other. The two forces which are equal in magnitude but opposite in direction form a couple. The resulting torque due to this couple rotates the loop, and the magnitude of the torque acting on the loop is proportional to the magnitude of the current passing through the loop.

If we increase the number of loops, the turning effect is greatly increased. This is the principle involved in electric motors.

Q.5 Write the construction and principle of working of DC motor.

Answer

Construction & working

I) A shown in fig. 15.9 that the simple coil placed in a magnet cannot rotate more than 90° The forces push the PQ side of the coil up and the RS side of the loop down until the loop reaches the vertical position. In this situation, plane of the loop is perpendicular to the magnetic field and the net force on the coil is zero.

So, the loop will not continue to turn because the forces are still up and down and balanced.

2) The coil can be rotated by reversing the direction of the current just as the coil reaches its vertical position.

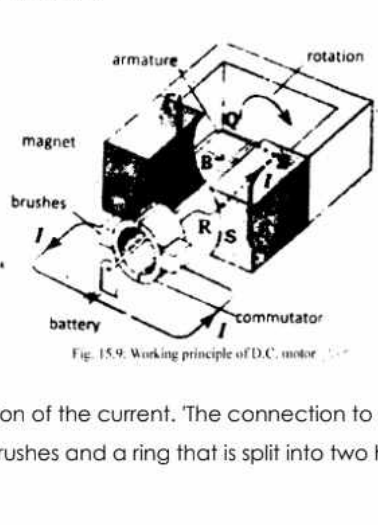


Fig. 15.9: Working principle of D.C. motor

3) This reverses direction of the current. 'The connection to coil is made through an arrangement of brushes and a ring that is split into two halves, called a split ring commutator.

4) Brushes. which are usually pieces of graphite, make contact which the commutator and allow current to flow into the loop. As the loop rotates. So does the commutator.

5) The split ring is arranged so that each half of the commutator changes brushes just as the coil reaches the vertical position. Changing brushes reverses the current in the loop. As a result, the direction of the force on each side of the

coil is reversed and it continuous to rotate. This process repeats at each half turn, causing coil to rotate in the magnetic field continuously. The result 15 an electric motor, which Is an apparatus that converts electric energy into rotational kinetic energy.

6) In a practical electric motor the coil, called the armature, is made of many loops mounted on a shaft or axle. The magnetic field is produced either by permanent magnets or by an electromagnet, called a field coil.

The torque on the armature, and as a result, the speed of the motor is controlled by varying the current through the motor.

The total force acting on the armature can be increased by:

i) Increasing the number of turns on the coil.

ii) Increasing the current in the coil.

iii) Increasing the strength of the magnetic field.

iv) Increasing the area of the coil.

Q.6 What is electromagnetic induction? Describe simple experiments to demonstrate that a changing magnetic field can induce an e.m.f. in a circuit?

Answer

Magnetic field strength

The strength of magnetic field is defined as the number of magnetic lines Of force passing through any surface.

1) The number of magnetic lines of force is maximum when the surface is held perpendicular to the magnetic lines of force as shown in figure 15.10.

2) It will be minimum when the surface is held parallel to the magnetic lines of force as shown in the figure 15.11.

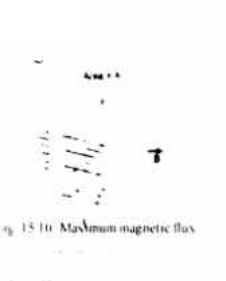


Fig. 15.10: Maximum magnetic flux

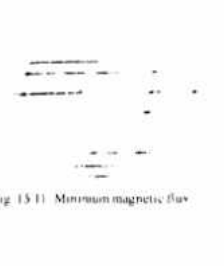


Fig. 15.11: Minimum magnetic flux

Electromagnetic Induction

The process of generating an induced current in a circuit by changing the number of magnetic lines of force passing through it is called electromagnetic induction.

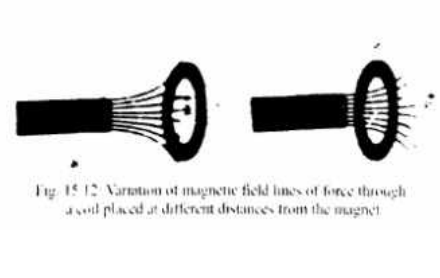


Fig. 15.12: Variation of magnetic field lines of force through a coil placed at different distances from the magnet

Explanation

If we place a coil in the magnetic field of a bar magnet, some of the magnetic lines of force will pass through it. If the coil is far away from the magnet, only a few lines will pass the coil as shown in the figure 15.12 (3).

However, if the coil is close to the magnet, a large number of lines of force will pass through it as shown in the figure 15.12 (b).

This means, we can change the number of magnetic lines of force through a coil by moving it in the magnetic field. This change in the number of magnetic field lines will induce an e.m.f in the coil.

Activity 1

Take a rectangular loop of wire and connect its two ends with a galvanometer. Now hold the wire stationary or move it parallel to the magnetic field of a strong U-shape magnet.

Galvanometer shows no deflection and hence there is no current.

1) Now, move the wire downward through the field, current is induced in one direction (fig. 15.13 a).

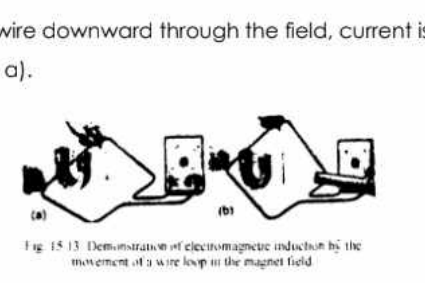


Fig. 15.13: Demonstration of electromagnetic induction by the movement of a wire loop in the magnet field

ii) Now move. the wire upward through the field, current is induced in the opposite direction (fig 15.13 b).

Activity 2

i) Take a solenoid and a magnet. When the magnet is stationary, no current is induced.

ii) When the magnet is moved towards the solenoid, the needle of galvanometer effects right, showing a current induced in the solenoid. "

iii) When the magnet is pulled away from the solenoid, the galvanometer deflects left, showing a current induced opposite in the solenoid.

Conclusion

It shows that due to relative motion between the coil and the magnet, an induced e.m.f or induced current is produced in the coil.

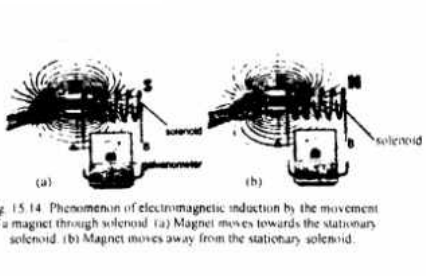


Fig. 15.14: Phenomenon of electromagnetic induction by the movement of a magnet through solenoid. (a) Magnet moves towards the stationary solenoid. (b) Magnet moves away from the stationary solenoid.

Q.7 State Faraday's law? How the direction of induced e.m.f is determined by Lenz's law?

Answer

Faraday's law

The value of induced e.m.f in a circuit is directly proportional to the rate of change of number of magnetic lines of force through it.

i.e $em.f = -N\frac{\Delta\varphi}{\Delta t}$

Or $em.f \propto \frac{\Delta\varphi}{\Delta t}$

Where, $\frac{\Delta\varphi}{\Delta t}$ is rate of change of magnetic field lines.

Len's law

"The direction of an induced current in a circuit is always such that it opposes the cause that produces it."

Explanation

If we bring a north pole of a bar magnet near a solenoid, an e.m.f will be induced in the solenoid by electromagnetic induction as shown in the figure 15.15 (a).

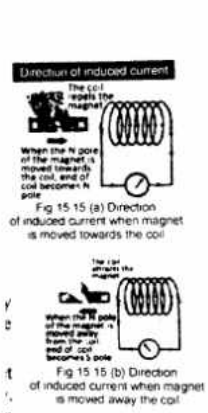


Fig 15.15 (a) Direction of induced current when magnet is moved towards the coil

Fig 15.15 (b) Direction of induced current when magnet is moved away the coil

The direction of the induced current in the solenoid by the induced emf will be such that it will repel the north pole of the magnet. This is only possible if the right end of the solenoid becomes a north pole.

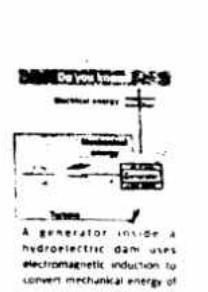
Hence, according to right hand grip rule, the direction of the induced current in the solenoid will be anticlockwise. Similarly, when we move the north pole of the magnet away from the solenoid. the direction of the induced current will be clockwise as shown in the figure 15.15 (b).

Mechanical energy of our hand used to push the magnet towards or away from the coil results into electrical energy. Hence Lenz's law is a manifestation of the law of conservation of energy.

Q.8 Write the working of A.C. generator? How current is produced from a generator?

Answer

A.C. Generator



A generator inside a hydroelectric dam uses electromagnetic induction to convert mechanical energy of a spinning turbine into electrical energy.

A device which converts 'the mechanical energy into electrical energy is called a generator. If it produces alternating current, it is called A.C. generator.

Working principle

If a coil is rotated in a magnetic field a current will be induced in the coil. The strength of this induced current depends upon the number of magnetic lines of force passing through the coil.

The number of lines of magnetic force passing through the coil will be maximum when the plane of the coil is parallel to the linew of force. This when a coil rotates in a magnetic field, the induced current in it continuously changes from maximum to minimum value and from minimum to maximum value and so on.

Connection:
A generator is a DC motor with its input and output reversed.

This is the basic principle on which an AC. generator works as shown in the figure 15.16.

1) The armature is arranged so that it can rotate freely in the magnetic field. As the armature turns, the wire loops cut through the magnetic field lines and induces e.m.f.

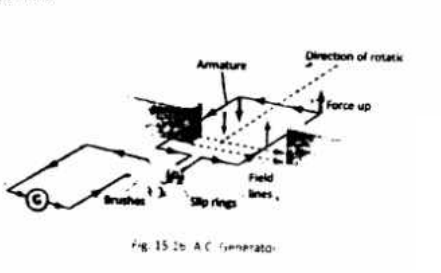


Fig. 15.16: A.C. Generator

2) The e.m.f. developed by the generator depends upon the length of the wire rotating in the field. Increasing the number of loops in the armature increases the wire length. thereby increasing the induced e.m.f.

Current from a generator

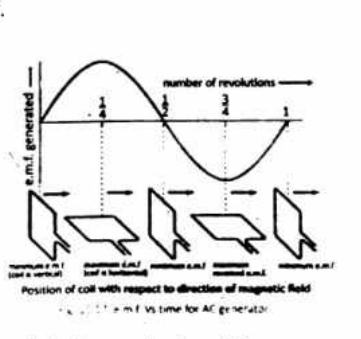


Fig. 15.17: e.m.f vs time for AC generator

When a generator is connected in a closed circuit, the induced emf. generates an electric current. As the loop rotates, the strength and the direction of the current changes as shown in the figure 15.17.

1) The current is minimum when' the plane of the loop is parallel to the magnetic field: when the loop is in the vertical position.

2) As the loop rotates from the vertical to the horizontal position. It cuts through larger magnetic field lines per unit of the times thus the e.m.f and the current increase.

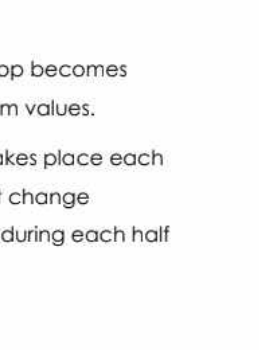
3) When the loop is in the horizontal position the plane of the loop becomes perpendicular to the field: so, the current reaches their maximum values.

4) As the loop continuous to turn, the change in the direction takes place each time the loop turns through 180º. Thus, the e.m.f and the current change smoothly from zero to some maximum values and back to zero during each half turn of the loop.

Q.9 What do you understand by the term mutual induction? Name and define SI unit if the mutual inductance?

Answer

Mutual Induction



The magnetic field of a coil is identical to the field of a disk shaped permanent magnet

"The phenomenon of production of Induced current in one coil due to change of current in a neighboring coil is called mutual induction."

Explanation

Suppose a system of two coils A & B placed close to each other as shown in the figure 15.18.

The coil A is connected to a battery and a switch, while a sensitive galvanometer is connected to the coil B. We observe that as soon as the switch of the coil A is closed, the galvanometer shows a momentary deflection.

Similarly, when the switch IS opened the galvanometer again shows a deflection but this time its direction is opposite to that of the previous case.

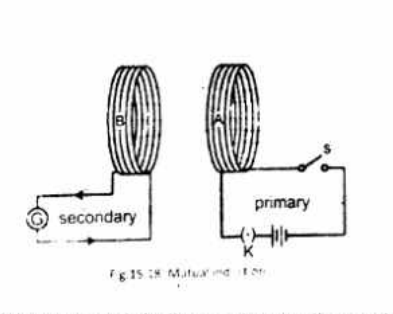
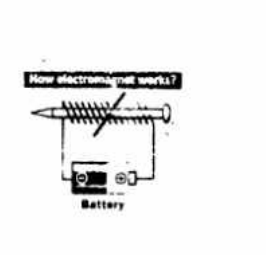


Fig. 15.18: Mutual induction

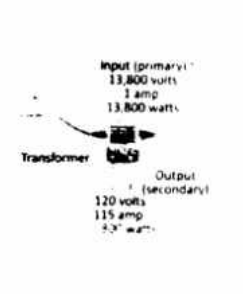


1) We can explain these observations using Faraday's Law of Electromagnetic Induction. When the switch of coil A is closed. It current is induced in the coil due to which magnetic field is developed across the coil.

2) Some of the magnetic lines of force of this field start passing through the coil 15. Since current is changing in the coil A, hence number of magnetic lines of force across the coil B also changes due to which a current is induced in the coil B in accordance with Faraday's law

3) When current in the coil A becomes steady, number of magnetic lines of force across the cod A also become constant. Therefore, there is no more change in the number of magnetic lines of force through the coil B due to which induced current in coil B reduces to zero.

4) Similarly, when the switch of the coil A is opened, the flow of current through it stops and, in few moments, its magnetic field reaches to zero. The number of magnetic lines of force through the coil B decreases to zero due to which current is again induced in it but in opposite direction to that in the previous case.



Q10 What is a transformer? Explain the working of transformer in 'connection with mutual induction?

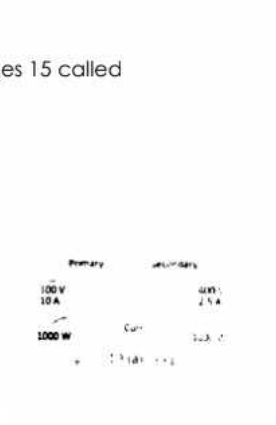
Answer

Transformer

"The device which is used to increase or decrease A.C voltages 15 called transformer."

It works on the principle of mutual induction.

Working of a transformer



A transformer has two coils, electrically insulated from each other, but wound around the same iron core. One coil is called "primary coil" and the' other coil is called "the secondary coil". Number of turns on the primary and the secondary coils are represented by N_P & N_s respectively. When the primary coil is connected to a source of A.C. voltage, the changing current creates a changing magnetic field, which is carried through the core to the secondary coil. In the secondary coil the changing field induces a varying e.m.f. This effect is called mutual inductance. The e.m.f. induced in the secondary coil, called the secondary voltage V_S, is proportional to the primary voltage V_D. These contrary voltages also depend on the ratio of the number of turns on the secondary coil to the number of turns on the primary coil, as shown by the following expression:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Step-up transformer

If the secondary voltage is larger than the primary voltage, the transformer is called a step-up transformer as shown in the figure 15. 19 (a).

Step down transformer

If the secondary voltage is smaller than the primary voltage, the transformer is called step-down transformer as shown in the fig. 15.19 (b).

Power formula

In an ideal transformer. the electric power supplied to the primary circuit. An ideal transformer dissipates no power itself and for such a transformer we can write:

$$P_p = P_s$$
$$V_p I_p = V_s I_s$$

Q.11 Briefly write about the high voltage transmission?

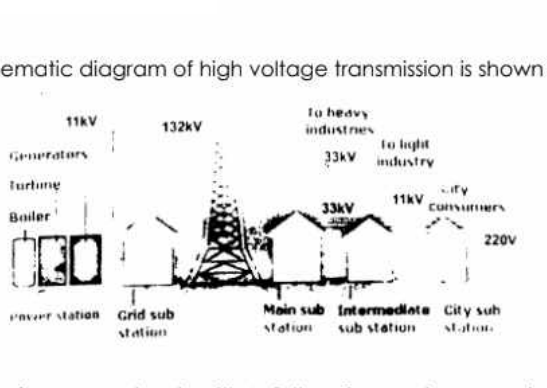
Answer

Electric power is usually generated at places which are far from the places where it is consumed. The power is transmitted over long distances at high voltage to minimize the loss of energy in the form of heat during transmission.

As heat dissipated in the transmission cable of resistance 'R' is I^2Rt. Hence by reducing the current '1' through the cable, power loss in the~ form of heat dissipation can also be reduced. So, the alternating voltage is stepped up at the generating station.

It is then transmitted to the main substation. This voltage is stepped down and is transmitted to the switch (grid-station) or the city sub-station. At the city- - substation it is further stepped down to 220 V and supplied to the consumers. A

schematic diagram of high voltage transmission is shown in figure 15.20.



Transformers work only with A.C therefore mains power is supplied at alternating current.

Q.12 Write any one application of electromagnet?

Answer

Electromagnet

Magnetic effect of current is called electromagnet. This effect is used in many devices like relay, electric bell etc.. Soft iron, gains and loses magnetism easily in such devices.

Relay

The relay is used to control a large current with the help of small current. A relay is an electrical switch that opens and closes under the control of another electrical circuit as shown in the fig. 15.21.

The 1st circuit (input circuit) supplies current to the electromagnet. The electromagnet is magnetized and attracts one end of the Iron armature. The armature then closes the contacts (2nd switch) and allows current to. flow in the second circuit.

When the first switch is- open again the current to the electromagnet stops. Now electromagnet loses its magnetism and the 2nd switch is opened. Thus, the flow of current stops in the 2nd circuit.

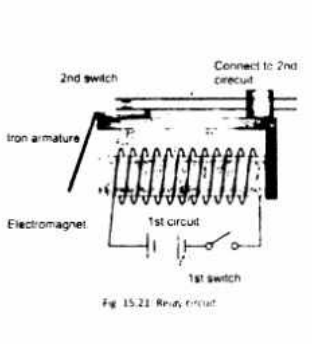


Fig. 15.21: Relay circuit

MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i. **Which statement is true about the magnetic poles?**
   - **a)** unlike poles repel
   - **b)** like poles attract
   - **c)** magnetic poles do not affect each other
   - **d)** a single magnetic pole does not exist

ii. **What is the direction of the magnetic field lines inside a bar magnet?**
   - **a)** from north pole to south pole
   - **b)** from south pole to north pole
   - **c)** from side to side
   - **d)** there are no magnetic field lines

iii. **The presence of a magnetic field can be detected by a:**
   - **a)** small mass
   - **b)** stationary positive charge
   - **c)** stationary negative charge
   - **d)** magnetic compass

iv. **If the current in a wire which is place to a magnetic field increases, the force on the wire:**
   - **a)** increases
   - **b)** decrease
   - **c)** remains the same

   - **d)** will be zero

v. **A D.C. motor converts:**
   - **a)** mechanical energy into electrical energy
   - **b)** mechanical energy into chemical energy
   - **c)** electrical energy into mechanical energy
   - **d)** electrical energy into chemical energy

vi. **Which part of a D.C. motor reverses the direction of current through the coil every half-cycle?**
   - **a)** the armature
   - **b)** the commutator
   - **c)** the brushes
   - **d)** the slip rings

vii. **The direction of induced e.m.f. in a circuit is in accordance with conservation of:**
   - **a)** mass
   - **b)** charge
   - **c)** momentum
   - **d)** energy

viii. **The step-up transformer:**
   - **a)** increases the input current
   - **b)** increases the input voltage
   - **c)** has more turns in the primary
   - **d)** has less turns in the secondary coil

ix. **The turn ratio of a transformer is 10. It means:**
   - **a)** $I_s = 10 I_p$
   - **b)** $N_s = N_p / 10$
   - **c)** $N_s = 10 N_p$
   - **d)** $V_s = V_p / 10$

ANSWERS

i. d **ii.** b **iii.** d **iv.** a **v.** c

vi. d **vii.** D **viii.** b **ix.** c

REVIEW QUESTIONS

[Note: Please see the answer of these question in the topics]

CONCEPTUAL QUESTIONS

15.1 Suppose someone? handed you three similar iron bars and told you one was not magnet but the other two were. How would you find the iron bar that was not magnet?

Answer

We shall plan the compass near each of the iron bar and will identify the magnetic nature of these iron bars. The iron bar which is not the magnet will not cause any deflection of the needle in the compass.

15.2 Suppose you have a coil of wire and a bar magnet. Describe how you could use them to generate an electric current.

Answer

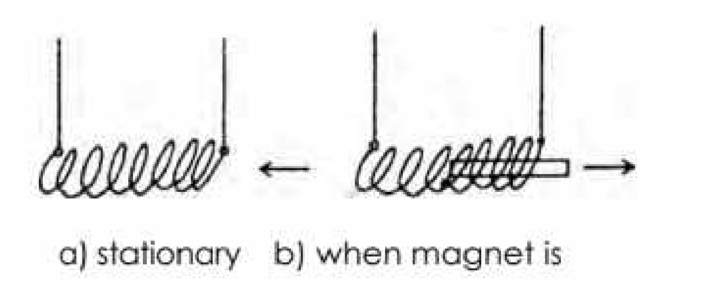
By moving the bar magnet towards the coil or by moving the coil towards the stationary magnet, the induced e.m.f. and induced current as well can be produced in the coil. This induced current will produce due change in the magnetic flux through the coil.

15.3 Which devise is used for converting electrical energy into mechanical energy?

Answer

Electric motor is used to convert electrical energy into mechanical energy.

15.4 Suppose we hang a loop of wire so that it can swing easily. If we now put a magnet into the coil, the coil will start swinging. Which way will it swing relative to the magnet and why?



a) stationary coil b) when magnet is placed inside

Answer

The coil will swing perpendicular to its cross-sectional area due to opposite polarity of magnet and coil according to Lenz's law.

15.5 A conductor wire generates a voltage while moving through a magnetic field. In what direction should the wire be moved, relative to the field to generate the maximum voltage?

Answer

The conductor wire should move perpendicular to the direction of magnetic field(lines) to produce a maximum (induced) voltage in it according to right hand rule.

15.6 What is the difference between a generator and a motor?

Answer

1. Generator converts mechanical energy into electrical energy.
2. Motor converts electrical energy into mechanical energy.

15.7 What reverses the direction of electric current in the armature coil of D.C. motor?

Answer

In case of D.C motor the direction of electric current is reversed due to split rings. (For detail please see the topic.)

15.8 A wire lying perpendicular to an external magnetic field carries of a current in the direction shown in the diagram below. In what direction will the wire move due to the resulting magnetic force?

Answer

By applying right hand rule the wire will move down perpendicular to the direction of magnetic field and current.

15.9 Can a transformer operate on direct current?

Answer [redacted]

No, a transformer can operate only on Alternating Current (A.C), because it operates on the principal of mutual induction which is obtained prominently in A.C. supply.

IMPORTANT SHORT QUESTIONS

Q2. Give short Answers.

1. Define magnetic field.

Answer

The region around a magnet where its magnetic effects are felt is called magnetic field.

2. What is the SI unit of magnetic field?

Answer

The SI unit of magnetic field is Tesla.

3. Write some magnetic effects of electric current?

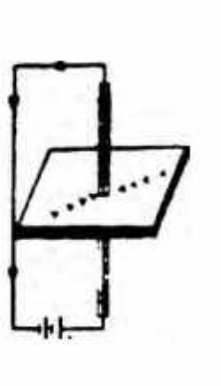
Answer

- When current passes through a conductor, magnetic field is produced in the space around it.
- If the conductor is a straight wire, these magnetic lines of force will be in the form of concentric circles.

4. What is line of magnetic force?

Answer

It is a line along which a small free north pole would move in a magnetic field.



5. How the direction of magnetic lines of force is determined?

Answer

The direction of the magnetic lines of force' can be determined by right hand rule.

Right hand rule:

If we grasp the current carrying conductor in our right hand with the thumb being stretched in the direction of current, the fingers would curl in the direction of the lines of force."

6. When do magnetic lines of force become clockwise?

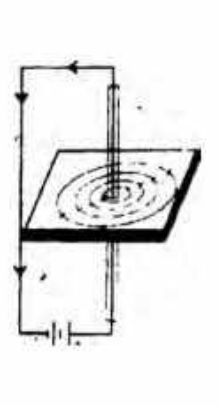
Answer

If the current flows from top towards the bottom the wire then the magnetic lines of force would be clockwise.

7. When do magnetic lines of force become anti-clockwise?

Answer

If the current flows from bottom towards the top of the wire then the magnetic lines of force would be anti-clockwise.



8. What does the symbol • and x mean?

Answer

- The dot (•) shows that the current iS directed out of the paper i.e. it is flowing towards us.
- A sign of cross (x) shows that the current is flowing away from us.

9. Write some characteristics of current carrying straight wire?

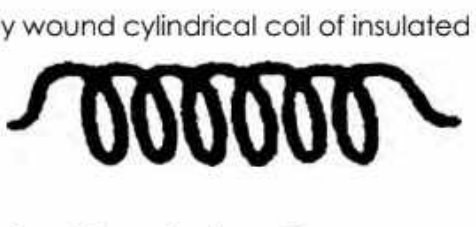
Answer

- A magnetic field is set up in the region surrounding a current carrying wire.
- The line of force is circular and their direction depends upon the direction of current.
- The magnetic field remains as long as the current is flowing in the wire.
- The strength of a magnetic is greater near the wire.
- Right Henrici, can determine the direction of the magnetic lines of force.

10. What is solenoid?

Answer

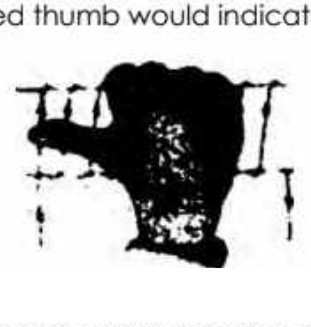
A solenoid is closely wound cylindrical coil of insulated wire.



11. How poles of solenoid can be found?

Answer

Hold the solenoid in your right hand by curling the finger in the direction of the current; the stretched thumb would indicate towards the North Pole.



12. How the direction of magnetic field of the solenoid is found?

Answer

The direction of magnetic of the solenoid is found by the use of Right-Hand Rule. It states that:

"Hold the solenoid in the right hand with fingers curling in the direction of, current, then the thumb will point in the direction of the magnetic field."

13. On what factors the strength of a magnetic field inside a solenoid depends?

Answer

The strength of a magnetic field inside a solenoid depends on the following factors:

- Current flowing in the solenoid.
- Number of turns per unit length.

- Medium inside solenoid.

14. Write some characteristics of current carrying solenoid?

Answer

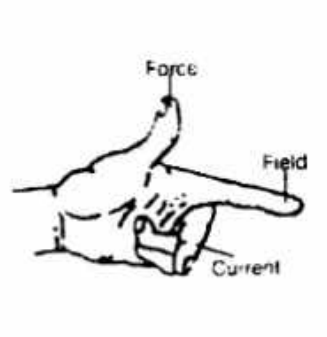
- Magnetic field inside the solenoid in uniform.
- Magnetic field inside the solenoid is large, as compared with outside the solenoid.
- Inside the solenoid, the lines of force are parallel and all point in the same direction.
- The Right-Hand Rule gives the direction of magnetic field.
- The current carrying solenoid. acts like-a bar magnet.
- The field at the coil is proportional to the current in the coil.

15. How the magnetic force is determined due to a current carrying conductor in a magnetic field?

Answer

When a current carrying conductor is placed in a magnetic field at right angles to it, it experiences a force, which is determined by Fleming's left-hand rule. According to this rule:

"Stretch the thumb, forefinger and the middle finger of the left hand mutually at right angles to each other. If the forefinger points in the direction of the current, then the thumb would indicate the direction of the force acting on the conductor."



16. On what factors the force on a current carrying conductor in a magnetic field depends?

Answer

The force on a current carrying conductor in a magnetic field depends upon the following factors:

- The current flowing through the conductor.
- Strength of the magnetic field.
- Length of the conductor.
- Angle between length and magnetic field of the conductor.

17. Why is magnetic field non-zero outside a solenoid?

Answer

As solenoid behaves as a bar magnet, so the magnetic field lines form a closed path, that is why the magnetic field is non-zero outside the solenoid.

18. How we increase the magnetic field in case of current carrying solenoid?

Answer

The magnetic field within the solenoid is increased by:

- Increasing the current in the wire.
- Increasing the number of turns per unit length.

19. Define mutual induction.

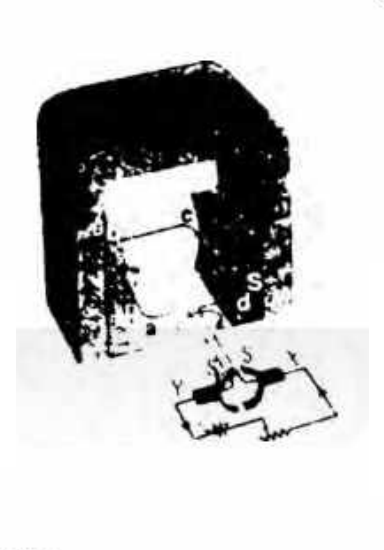
Answer

The phenomenon in which a changing a current in one coil induces an emf in another coil is called the mutual induction.

20. What is D.C motor? Draw its diagram.

Answer

A D.C motor is a device, which converts electrical energy into mechanical energy.



21. Give the principle of D.C motor.

Answer

When a current carrying wire is placed in a magnetic field, it experiences a force. This is the basic principle of an electric motor.

22. Define induced emf.

Answer

An emf is induced in a conductor when it moves in a magnetic field, is called an induced emf.

23. What is induced current?

Answer

The current produced by moving a loop of wire in the magnetic field is called induced current.

24. On what factors the induced current depends?

Answer

Induced current depends upon the following factors:

- The speed with which the conductor moves in the magnetic field.
- Resistance of the loop.

25. How induced current can be increased?

Answer

The induced current can be increased:

- Using a strong magnetic field.
- Moving the loop faster.
- Replacing the loop by a coil of many turns.

26. What is electromagnetic induction?

Answer

The production of an electromotive force either by motion of a conductor through a magnetic field or by a change in the Magnetic flux is known as electromagnetic induction.

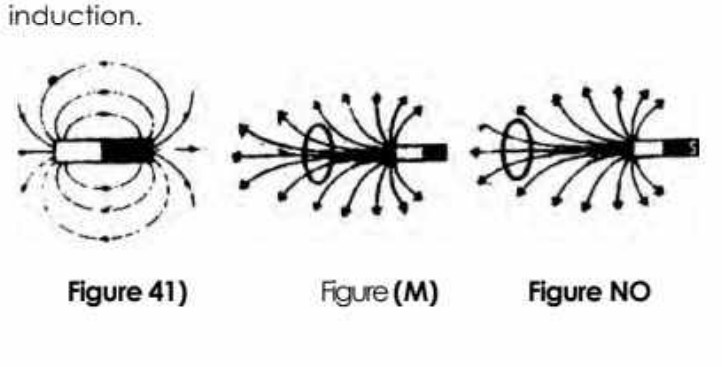


Figure 41) Figure (M) Figure NO

27. What is magnetic flux?

Answer

The number of magnetic lines passing through any surface is known as the magnetic flux through that surface.

28. State Faraday's law of electromagnetic induction?

Answer

Faraday's law of Electromagnet Induction is stated as:

"The value of the induced e.m.f is directly proportional to the rate of change of flux." Mathematically,

$$\text{Induced}\ emf = N\frac{\Delta\varphi}{\Delta t}$$

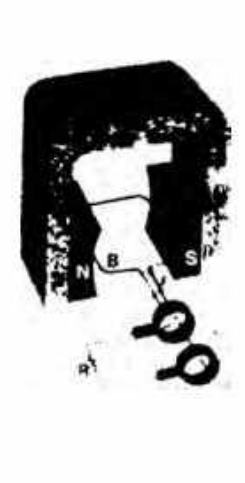
Where N = number of turns of the coil

$\frac{\Delta\varphi}{\Delta t}$ = Rate of change of flux

28. What is A.C generator? Draw its diagram.

Answer

A device, which converts mechanical energy into electrical energy, is called current generator. A generator, which produces alternating voltage and current is called A.C generator.



29. Give its principle.

Answer

The principle of an electric generator is based on Faraday's law of electromagnetic induction.

30. Name the main parts of an A.C generator.

Answer

These are following main parts of an A.C generator.

1) A coil of many turns 2) Sliprings
3) Brushes 4) A permanent magnet

31. What are the similarities between a motor and a generator?

Answer

A motor and a generator are similar in following way:

- Both require magnetic field produced by a permanent magnet.
- Both have a coil capable of rotation.
- Both have split rings.

- Both work on the principle of Faraday's law of electromagnetic induction.
- Both of them have carbon brushes.

32. What are the differences between a motor and a generator?

Answer

A motor and a generator are different in following ways:

- A motor converts electrical energy into mechanical energy, while a generator converts mechanical energy into electrical energy.
- In a motor, electric current is supplied to the coil that causes it to rotate in the outer magnetic field while in a generator, the coil is rotated in the magnetic field due to which emf is induced in the coil.

33. What is mutual induction?

Answer

If the current is induced in a circuit due to change of current in another circuit, this phenomenon is known as mutual induction.

34. Differentiate between primary and secondary coil?

Answer

The coil to which A.C voltage is supplied is called primary coil while the coil from which power is delivered to the circuit is called secondary coil.

35. How some birds like pigeon, correctly estimate the direction?

Answer

There is some sort of natural magnet in their head to estimate the direction correctly.

36. What is self-induction?

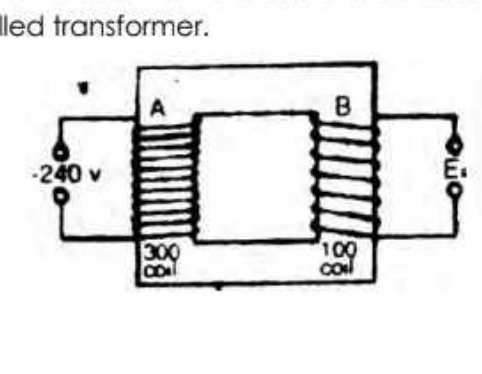
Answer

If the current through a coil or a circuit changes and this change induces an emf in the circuit itself, the phenomenon is known as self-induction.

37. What is transformer?

Answer

An electrical device, which is used to increase or decrease the value of alternating voltage, is called transformer.



38. Give the principle of transformer.

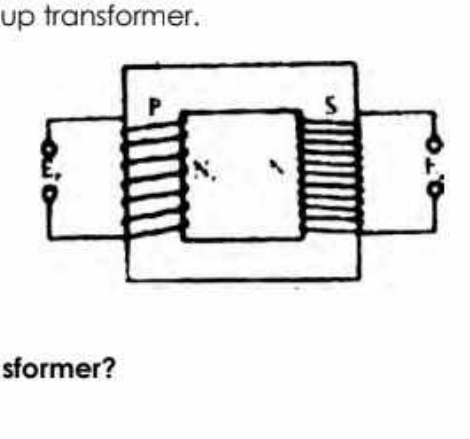
Answer

It works on the principle of mutual induction between two coils.

39. Define step-up transformer?

Answer

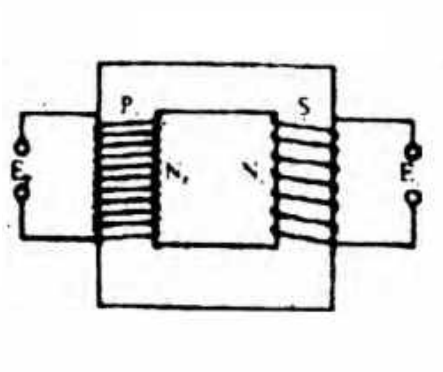
Such a transformer in which voltage across secondary coil is greater than the primary coil is called step-up transformer.



40. Define step-down transformer?

Answer

Such a transformer in which voltage across secondary coil is less than the primary coil is called step-up transformer.



41. Why two lines of forces never intersect each other?

Answer

If two lines of force intersect at a point, then there will be two directions of resultant magnetic field at that point, which is impossible. Hence two lines of force never intersect each other.

42. Can a transformer operate on D.C?

Answer

A transformer cannot operate on steady or changing D.C voltage.

43. Why we use A.C to operate the transformer?

Answer

It requires a voltage, which rises and falls. Since an A.C voltage not only changes its magnitude but its direction as well. So, it is used to operate transformer.

44. Write the equation of the transformer.

Answer

The relation for a transformer is given by:

$$\frac{E_s}{E_p}=\frac{N_s}{N_p}$$

Where

N_p = Number of turns in the primary coil
N_s = Number of turns in the primary coil
E_p = voltage applied across the primary coil
E_s = the required voltage generated across the secondary coil

45. On what factors the output voltage depends in a transformer?

Answer

The output voltage of a transformer depends upon the following factors:

- Number of turns in the primary coil.
- Number of turns in the secondary coil.
- Soft iron core.

46. How magnetic field can be set?

Answer

Magnetic field can be set up around a conductor due to the flow current through a conductor.

47. Show the presence of magnetic field around a current carrying coil?

Answer

According to Oersted, moving charges rise to a magnetic field around the wire, which appears in the form of concentric circles around the conducting wire and remains present as long as current is flowing.

48. A current carrying wire is placed in a magnetic field, how must it be oriented so that the force on it is zero.

Answer

When the current carrying conductor is placed in such a way that the direction of current is parallel to lines of magnetic field, the force on it is zero because:

$$F = BIL\sin\theta$$

Hence $F = 0$ when $\theta = 0^0$

49. A current carrying wire is placed in a magnetic field, how must it be oriented so that the force on it is maximum.

Answer

When the current carrying conductor is placed in such a way that the direction of current is perpendicular to lines of magnetic field, the force on it is maximum because

F will be maximum when $\theta = 90^0$

$$F = BIL\sin\theta$$

$$F = BIL\times\sin 90^0$$

$$F = BIL$$

Multiple Choice Question

QI. Each question is followed by four options encircle the correct option.

1) The shape of magnetic lines of force in case of a straight current carrying conductor is:

a. elliptical b. triangular
c. rectangular d. circular

2) When a straight current carrying conductor is placed in a magnetic field at right angles to it, the direction of force acting upon it is:

a. the same as the direction of field
b. opposite to the direction of the field
c. makes an angle of 45° with the current
d. at right angles to both the field and the current

3) A transformer has 100 turns in the primary and 500 turns in the secondary. If 6 volts is applied across its primary, the voltage induced across its secondary would be:

a. 0 volts b. 30 volts
c. 45 volts d. 60 volts

4) Select the statement which is not true:

a. The value of induced e.m.f is inversely proportional to the rate of change of flux
b. When there is relative motion between the coil, and the magnet, induced e.m.f. is produced
c. Michael Faraday discovered Faraday's law of electromagnetic induction in 1831
d. Change of flux induces an e.m.f. in the coil

5) Which statement is not correct?

a. magnetic lines of force can be drawn in any magnetic field
b. If a coil is placed in the magnetic field of a bar magnet, some lines of force will pass through its face
c. A solenoid cannot be connected with a galvanometer
d. Battery contains chemical energy in it

6) The D.C. motor converts, electrical energy of battery into

a. kinetic energy b. mechanical energy
c. potential energy d. sound energy

7) Which is not correct according to Fleming's left hand rule?

a. The forefinger points in the direction of magnetic field
b. The middle finger points in the direction of current
c. The thumb indicates the direction of force
d. The thumb indicates the direction of current

8) Who discovered electromagnetic induction?

a. Volta b. Ohm
c. Michael Faraday d. Maxwell

9) Which indicates the number of turns in primary coil?

a. E_P b. E_s
c. N_p d. N_s

10) Which equation is true?

a. $\frac{E_s}{E_p}=\frac{N_s}{N_p}$ b. $E_p=\frac{N_p}{N_s}\times\frac{1}{E_s}$ c. $\frac{N_s}{E_p}=\frac{N_p}{E_s}$ d. $\frac{N_p}{E_p}=\frac{E_p}{N_s}$

11) Which statement is not true about A.C. generator?

a. it consists of a rectangular coil
b. coil rotates between two poles of permanent magnet
c. both the ends are soldered to five slip rings
d. there are two carbon brushes present in it

12) Which statement is not true about transformer?

a. transformer is used to increase or decrease the value of alternative voltage
b. it consists of five coils
c. it consists of two coils
d. one coil is called primary coil

13) When current passes through a conductor, which of the following produces around the conductor?

a. electric field b. magnetic field
c. gravitational field d. none of these

14) The magnetic lines of force can be traced by using a:

a. magnetic pen b. tracing paper
c. compass needle d. lead pencil

15) The magnetic lines of force in the form of concentric circles if conductor is:

a. straight b. curve
c. circle d. rectangle

16) According to right hand rule if current is flowing through the wire in upward direction, then the direction of magnetic field will be:

a. upward b. clockwise
c. downward d. anti-clockwise

17) The direction out of plane of the paper is indicated by:

a. cross (x) b. dot (•)
c. plus (+) d. negative (—)

18) The magnetic lines are straight and parallel in a small region near the:

a. centre of coil b. left side of coil
c. right side of coil d. out side of coil

19) A closely wound cylindrical coil of insulated wire is called:

a. lever b. current carrying coil
c. solenoid d. inductor

20) Inside the solenoid magnetic lines of force are:

a. cancel each other b. parallel
c. in the same direction d. both (c) and (d)

21) The direction of current or magnetic field into the plane of paper is indicated by the symbol:

a. + b. x
c. d. -

22) The angle between current, magnetic field and force is:

a. 0° b. 45^0
c. 90° d. 180°

23) Fleming's left-nand rule is used to determine the direction of:

a. force b. current
c. electric field d. e.m.f

24) If the conductor is placed parallel to the field, then the force acting upon it is:

a. maximum b. zero
c. small deflection towards left d. large deflection towards right

25) A D.C. motor consists of:

a. a coil b. split ring
c. a U shape magnet d. all of these

26) Fleming's left hand rule is also known as:

a. Kirchhoff's rule b. Ohm's law
c. motor rule d. none of these

27) D.C. motors converts electrical energy into:

a. magnetic energy b. mechanical energy
c. heat energy d. light energy

28) In bar magnet magnetic lines are started from:

a. north pole b. south pole
c. centre d. none of these

29) If the magnetic flux through a coil or solenoid is changed, then:

a. it will rotate b. e.m.f is induced
c. coil oscillate d. coil becomes stationary

30) Farady's law of electromagnetic induction is the principle of:

a. magnetism b. electromagnetism
c. induced e.m.f d. electric field

31) The device which converts mechanical energy into electrical energy:

a. motor b. generator
c. battery d. thermocouple

32) A.C. generator works on the principle of:

a. induced e.m.f b. motor principle
c. Fleming's law d. Joule's law

33) An A.C. generator consists of:

a. rectangular coil b. U shape magnet
c. slip ring. d. all of these

34) A.C. in Pakistan has a frequency of:

a. 10 Hz b. 20 Hz
c. 40 Hz d. 50 Hz

35) Rate of change of current in a coil produces induced current in other coil, this is known as:

a. induced e.m.f b. self induction
c. mutual induction d. none of these

36) The S.I. unit of mutual induction is:

a. Tesla b. Henery
c. Weber d. Weber m-2

37) If rate of change of current produces e.m.f in the same coil, it is called:

a. self induction b. mutual induction
c. induced e.m.f d. conductance

38) The S.I. unit of self induction is:

a. Henery b. Tesla
c. Weber d. Weber m^{-2}

39) The principle of transformer is:

a. law of electromagnetic induction b. mutual induction
c. self induction d. lens law

40) Number of primary toils is represented by:

a. N_s b. E_T,
c. E_s d. N_p

41) In step up transformer:

a. $N_p > N_s$ b. $N_s > N_p$
c. $E_s > E_p$ d. both (b) and (c)

42) In step down transformer:

a. $N_p > N_s$ b. N_s > Np
c. $E_s > E_p$ d. both (b) and (c)

43) In transformer, the strength of magnetic field increases by using:

a. iron core b. wood core
c. brass core d. air core

44) E_p stands for:

a. voltage at secondary b. voltage at primary
c. no of turns at primary d. no of turns at secondary

45) In A.C. generator, flux will be zero if coil is:

a. horizontal b. vertical
c. parallel d. inclined

46) Voltage is increased by using transformer which is:

a. step down b. step up
c. by increasing magnetic field d. increasing no of turn in primary coil

47) Number of turns in secondary coil is represented by symbol:

a. E_p b. E_s
c. N_s d. N

48) When current passes through solenoid, it behaves like a:

a. bare magnet b. D.C. motor
c. A.C. generator d. transformer

49) If curl of lingers of right hand shows the direction of current in solenoid, then thumb indicates:

a. flow of current b. direction of voltage
c. north pole d. south pole

50) If a coil moves parallel to magnetic field, the induced e.m.f will be:

a. maximum b. zero
c. negative d. positive

ANSWERS

No	Ans	No	Ans	No	Ans	No	Ans
1	d	**2**	d	**3**	d	**4**	a
5	c	**6**	b	**7**	b	**8**	c
9	c	**10**	a	**11**	c	**12**	b
13	b	**14**	c	**15**	a.	**16**	d
17	b.	**18**	a	**19**	c	**20**	d
21	b	**22**	c	**23**	a	**24**	b
25	d	**26**	c	**27**	b	**28**	a
29	b	**30**	c	**31**	b	**32**	a