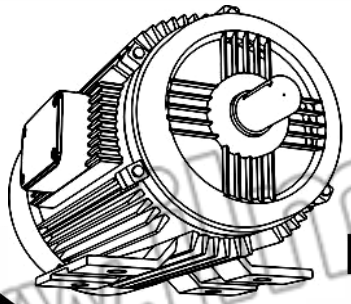


UNIT 15

ELECTROMAGNETISM

15.1 MAGNETIC EFFECTS OF A STEADY CURRENT
15.2 FORCE ON A CURRENT – CARRYING CONDUCTOR PLACED IN MAGNETIC FIELD

LONG QUESTIONS

Q.1 Demonstrate by an experiment that a magnetic field is produced around a straight current carrying conductor also state the rule by which direction of the lines of force of magnetic field around a current carrying conductor can be determined? Also described clockwise and anticlockwise direction of magnetic field. ***(K.B+U.B+A.B)*** **(FSD 2016), (Review Ex. 15.1)**

Ans: **MAGNETIC EFFECTS OF A STEADY CURRENT**

Introduction:

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

Experiment:

To demonstrate this, we take straight, conductor wire and pass it vertically through a cardboard. Now connect the two ends of the conductor wire with the terminals of the battery so that current flows through the circuit in the clock wise direction. The lines of force of the magnetic field produced around the wire would be in the form of concentric circles. If we place 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 filings on the cardboard around the wire, they will align themselves in concentric circles in the clockwise direction.

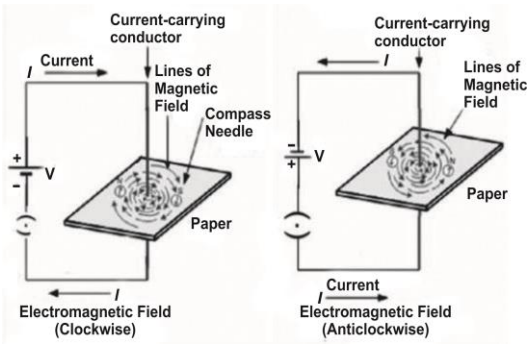


Figure: **Electromagnetic Field (Clockwise) & (Anticlockwise)**

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 anticlockwise direction. The magnetic field produced is stronger near the current–carrying conductor and weaker farther away from it.

Direction of Magnetic Field:

The direction of the magnetic field is governed by the direction of the current flowing through the conductor. A simple method of finding the direction of magnetic field around the conductor is the Right Hand Grip Rule.

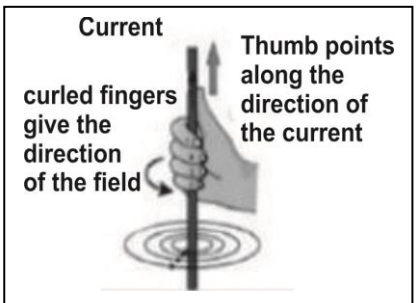


Figure: **Right Hand Grip Rule**

Right Hand Grip Rule:

"Grasp a wire with your right hand such that, your thumb is pointed in the direction of the (positive) current. Then curling fingers of your hand will point in the direction of the magnetic field**"**.

Q.2 What is solenoid? Explain magnetic field produced in current carrying solenoid. ***(K.B+U.B)***

OR

Explain magnetic field produced solenoid in resents to bar magnet. **(FSD 2016)**

Ans:

SOLENOID

Definition:

"A long coil of wire consisting of many loops is called a solenoid**"**.

MAGNETIC FIELD OF A SOLENOID

The field from each loop in a solenoid adds to the fields of the other loops and creates greater total field strength. Electric current in the solenoid of wire produces magnetic field which is similar to the magnetic field of a permanent bar magnet. When this current – carrying solenoid is brought close to a suspended bar magnet, one end of the solenoid repels the north pole of the bar magnet. Thus, the current – carrying solenoid has a north and a south pole and use itself a magnet.

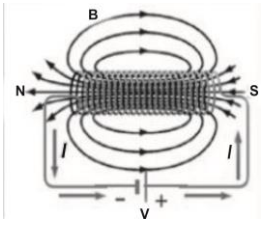


Figure: Magnetic Field due to a solennoid

Electromagnet:

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

Direction of the Magnetic Field:

The direction of the field produced by a coil due to the flow of conventional current can be found with the help of right hand grip rule.

Right Hand Grip Rule:

If we grip the coil with our right hand by curling our fingers in the direction of the conventional current, our thumb will indicate the north of the coil.

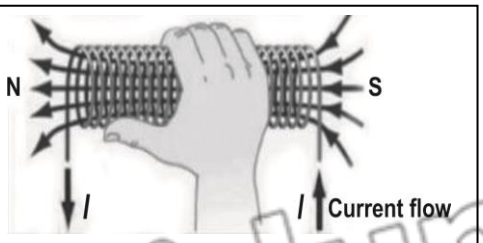


Figure: Right Hand Grip Rule for a Coil

Q.3 Explain When a straight current-carrying conductor is placed in a magnetic field, it experiences a force. State the rule by which the direction of this force can be found out. ***(K.B+U.B+A.B)***

Force on a current-carrying conductor placed in a magnetic field:

Ans:

FORCE ON A CURRENT – CARRYING CONDUCTOR

Electric current produces a magnetic field similar to that of a permanent magnet. Since a magnetic field exerts a force on a permanent magnet, it implies that current-carrying wire should also experience a force when placed in a magnetic field.

Explanation:

The force on a wire in a magnetic field can be demonstrated using the arrangement. 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 on the direction of the current, the force on the wire either pushes or pulls it towards right or toward left.

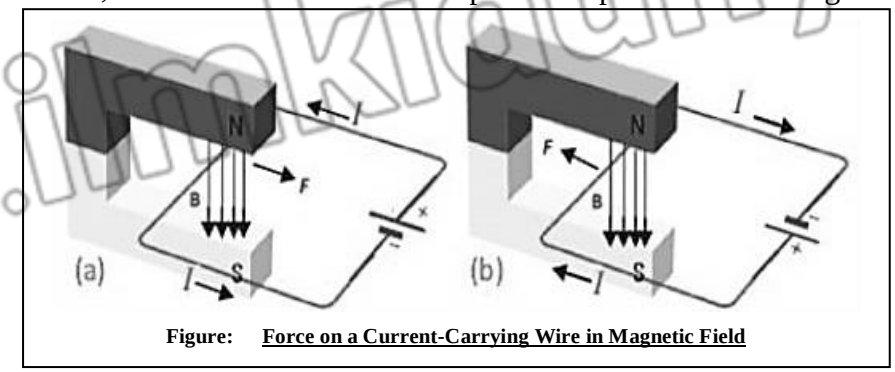


Figure: **Force on a Current-Carrying Wire in Magnetic Field**

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 the current.

Factor Affecting the Force:

The force is increased if

- The current in the wire is increased
- Strength of magnetic field is increased
- The length of the wire inside the magnetic field is increased

Determining the Direction of Force:

Faraday's description of the force on a current-carrying wire does wire does not completely specify the direction of force because the force can be towards left or towards right. The direction of the force on a current – carrying wire in a magnetic field can be found by using Fleming's left hand rule started as:

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**"**.

The force acting on the conductor is at right angle to both the direction of current and magnetic field according to flaming left hand rule.

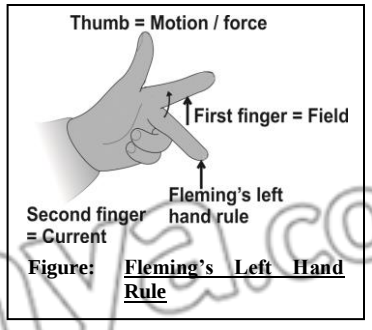


Figure: **Fleming's Left Hand Rule**

15.1, 15.2 SHORT QUESTIONS

Q.1 How magnetic lines of force are formed in the straight current carrying conductor? ***(K.B)***

Ans: **FORMATION OF MAGNETIC LINES**

When current passes through a conductor, a magnetic field is produced around it. If the conductor is a straight wire, the lines of force of this magnetic field would be in the form of concentric circles. These lines of force can be traced on a piece of cardboard with the help of a compass needle. It will align along the direction of magnetic field.

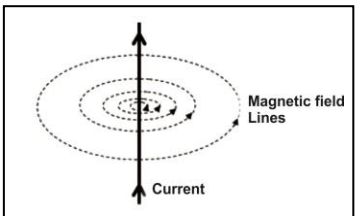


Figure: **Direction of Magnetic Field Lines**

Q.2 What is Right Hand Grip Rule? ***(K.B)***
OR 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.
(LHR 2015, 2016, FSD 2016, 17, SGD 2016, DGK 2016), (Review Ex. 15.2)

Ans: ***Given on Page # 274***

Q.3 Write down the rules to find the polarity of solenoid. ***(K.B)*** **(RWP 2016)**

Ans: ***Given on Page # 275***

Q.4 State Fleming's Left Hand Rule. ***(K.B)***
OR You are given an unmarked magnetized steel bar and bar magnet, its north and south ends are marked N and S respectively. State how you would determine the polarity at each end of the unmarked bar?
(GRW 2015, FSD 2016, 2017, SGD 2016, MTN 2016) , (Review Ex. 15.4)

Ans: ***Given on Page # 276***

Q.5 When the force on the current carrying conductor in a magnetic field is maximum and when it is minimum? ***(K.B)***

Ans:

MAGNITUDE OF FORCE

When the current carrying conductor makes an angle of 90^0 with the magnetic field or it is perpendicular to the field, force on it is maximum. If the conductor is placed along or parallel to the magnetic field, no force acts on the conductor.

Q.6 What is difference between magnetism and electricity? ***(K.B)***
(Interesting information Pg. # 119)

DIFFERENTIATION

Ans: Following are the differences between Magnetism and Electricity.

Electricity	Magnetism
Separation	
• Electric charges can be separated into a single type.	• Magnetic poles cannot be separated.
Example	
• We have a single negative charge or a single positive charge.	• It is not possible to have a magnetic north pole without a magnetic south pole.

Q.7 What is MRI? ***(A.B)*** **(Interesting information Pg. # 119)**

Ans:

MRI

Weak ionic current in our body that travels along the nerves can produce the magnetic effect. This forms the basis of obtaining images of different parts of body. This is done using the technique called Magnetic Resonance Imaging (MRI). Heart and brain are two main organs where significant magnetic fields can be produced. Using MRI doctors can diagnose the disorders of brain and heart etc.

Q.8 What is an electromagnet? ***(K.B)*** **(LHR 2017, GRW 2016, 2017, RWP 2016, MTN 2016)**

Ans:

ELECTROMAGNET

"The type of temporary magnet, which is created when current flows through the coil, is called an electromagnet**"**.

CONSTRUCTION

- Solenoid
- Iron core
- Battery

Q.9 What is meant by electromagnetism and write its applications? ***(K.B+A.B)***

Ans:

ELECTROMAGNETISM

"Electromagnetism is the study of magnetic effects of current".

Ans:

APPLICATIONS

The practical applications of electromagnetism are:

- Motors and electric meters are based on the effect or magnetism produced by the electric current in wires.
- Generators produce electric current due to the movement of wires near very large magnets.

Q.10 What is Solenoid? ***(K.B)*** **(FSD 2017)**

Ans: ***Given on Page # 275***

Q.11 What was the discovery of Ampere? ***(K.B)***

Ans:

DISCOVERY OF AMPERE

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

Q.12 Illustrate diagrammatically the similarity between magnetic field of a bar magnet and that of a coil. ***(K.B)*** **(For your information Pg. # 121)**

Ans:

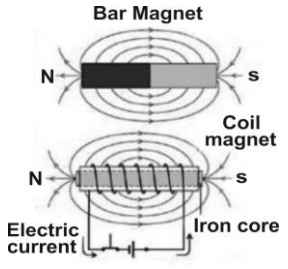


Figure: Magnetic Field due to a solennoid

Q.13 What are the factors which increase force on a current carrying conductor? ***(K.B)***

Ans:

FORCE ON A CURRENT CARRYING

The force is increased if:

- The current in the wire is increased
- Strength of magnetic field is increased
- The length of the wire inside the magnetic field is increased.

Q.14 What is difference between hard magnetic material and soft magnetic material?

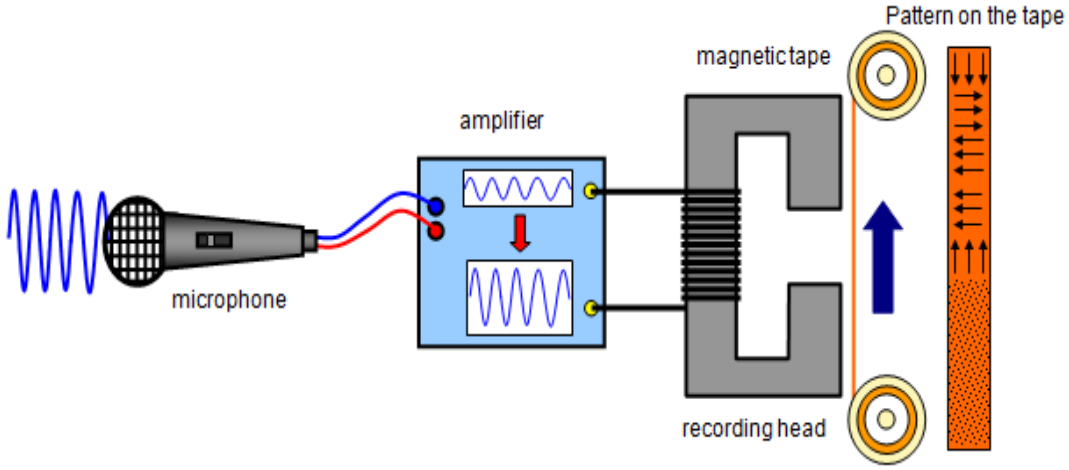
Ans:

DIFFERENTIATION

Hard Magnetic Material	Soft Magnetic Material
• A hard magnetic material (for example, steel) is one which, when magnetized, does not readily lose its magnetism.	• A soft magnetic material (for example, iron) quickly loses its magnetism when the magnetizing field is removed.

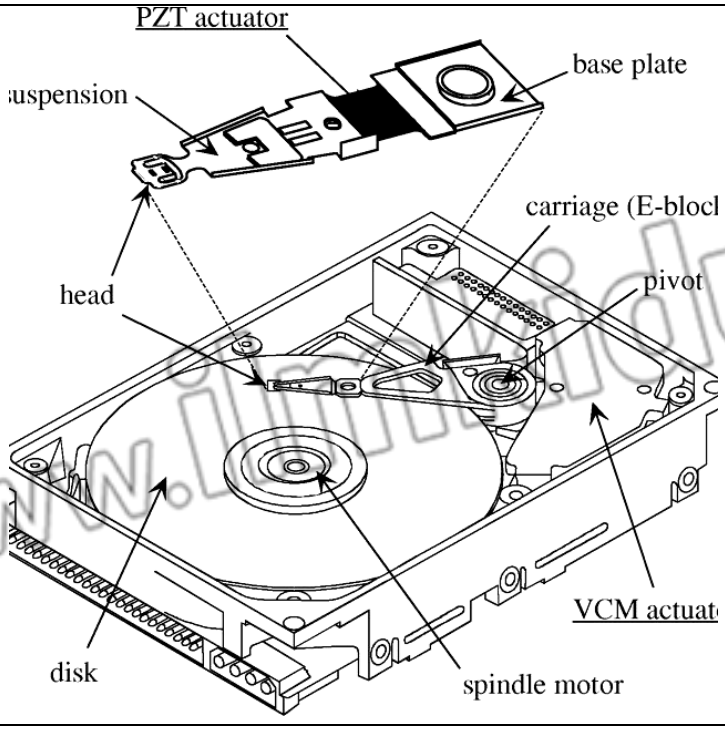
Q.15 What is magnetic storage?

Ans: TV studios use magnetic tape, in cassettes, for recording pictures and sounds. The tape consists of a long, thin plastic strip, coated with a layer of iron oxide or similar material. Magnetically, iron oxide is between soft and hard. Once magnetized it keeps its magnetism, but is relatively easy to demagnetize, ready for another recording. The diagram below shows a simple system for recording sound on tape. The hard drive in a computer also stores data as a pattern of varying magnetism. In both examples, an electromagnet creates the varying magnetic field need for recording. Later, a play back head can read the pattern to give a varying current.



Recording on Magnetic Tape:

The incoming sound waves are used to vary the current in a tiny electromagnet in the recording head. As the tape moves past the head, a track of varying magnetism is created along the tape.



Computer hard drive:

The recording head is at the end of the arm. It contains a tiny electromagnet which is used to create tracks of varying magnetism on a spinning disc. The disc is made of aluminium or glass, and is coated with a layer of magnetic material similar to that on a tape.

Q.16 How to make a magnet and demagnetize a magnet?

Ans: **DIFFERENTIATION**

Making a Magnet	Demagnetizing a magnet
• A steel bar has been placed in a solenoid. When a current is passed through the solenoid, the steel becomes magnetized and makes the magnetic field much stronger than before. And when the current is switched off, the steel stays magnetized. Nearly all permanent magnets are made in this way.	• A magnet is slowly being pulled out of a solenoid through which an alternating current is passing. Alternating current (a.c) flows backwards, forwards, backwards, forwards…. And so on. It produces a magnetic field which changes direction very rapidly and throws the atoms in the magnet out of line.

Q.17 What is difference between permanent magnetic field and electromagnetic field?

Ans: **DIFFERENTIATION**

Permanent Magnetism	Electromagnetism
• Magnetism is permanent unless it damaged. • Magnetism is weaker as compared to electromagnetism. • Its strength cannot be changed.	• Magnetism is temporary and can be switched on or off. • Magnetism is much stronger as compared to permanent magnetism. • Its strength can be changed. • Electromagnetism is more beneficial in our daily life.

15.1, 15.2 MULTIPLE CHOICE QUESTIONS

1. _____ is a study of magnetic effects of current: ***(K.B)***

(A) Electrostatics (B) Electricity
(C) Electromagnetism (D) Electronics

2. Who discovered that when current passes through a conductor it produces a magnetic field around it: ***(K.B)***

(A) Lenz (B) Coulomb
(C) Ampere (D) Faraday

3. When current passes through straight conductor it produce magnetic field in the form of: ***(K.B)***

(A) Straight line (B) Concentric circles
(C) Rectangular form (D) Parabolic shape

4. The magnetic field produced in straight current carrying conductor is stronger: ***(K.B)***

(A) Near pole (B) Near current carrying conductor
(C) Away from current carrying conductor (D) None of these

5. The magnetic field produced in straight current carrying conductor is weaker: ***(K.B)***

(A) Near pole (B) Near current carrying conductor
(C) Away from current carrying conductor (D) None of these

6. Weak ionic current that travel along the nerve can produce the _____.*(K.B)*

(A) Electric effect (B) Magnetic effect
(C) Electric and Magnetic field (D) All of these

7. MRI stands for: ***(K.B)***
(A) Magnetic resonance imagining (B) Magnetic resistance and current
(C) Magnetic resistance imaginary (D) None of these

8. The magnetic lines of force can be traced on cardboard by using: ***(K.B)***
(A) Cardboard (B) Compass Needle
(C) Paper (D) Magnet

9. Shape of magnetic lines of force in straight conductor are: ***(K.B)***
(A) Straight (B) Elliptical
(C) Circular (D) All of them

10. Direction of magnetic lines of force in straight conductor is found by: ***(K.B)***
(A) Right hand rule (B) Left hand rule
(C) Both a & b (D) None of them

11. If the current is flowing from bottom to top then the direction of magnetic lines of force will be: ***(K.B)***
(A) Anti-Clockwise (B) Clockwise
(C) Straight (D) None of them

12. If the current is flowing from top to bottom then the direction of magnetic lines of force will be: ***(K.B)***
(A) Anti-Clockwise (B) Clockwise
(C) Straight (D) None of them

13. Magnetic field in most part of the coil is: ***(K.B)***
(A) Circular (B) Straight
(C) Uniform (D) Non-Uniform

14. A closely wound cylindrical coil of insulated wire is: ***(K.B)***
(A) Cylindrical coil (B) Solenoid
(C) Cable (D) All of them

15. Magnetic lines of force in solenoid are: ***(K.B)***
(A) Circular (B) Parallel
(C) Non-Uniform (D) Uniform

16. Lines of force in solenoid resemble the pattern of lines of force due to: ***(K.B)***
(A) Electromagnet (B) Horseshoe magnet
(C) Bar magnet (D) All of them

17. The polarity of current carrying solenoid is found by: ***(K.B)***
(A) Right Hand Rule (B) Left Hand Rule
(C) Both a & b (D) None of them

18. Hold down the end of the current carrying solenoid in front of you, if the direction of current flow through this end is anti-clock wise it would be: ***(K.B)***
(A) North Pole (B) South Pole
(C) Any of them (D) None of them

19. Hold down the end of the current carrying solenoid in front of you, if the direction of current flow through this end is clockwise it would be: ***(K.B)***
(A) North Pole (B) South Pole
(C) Any of them (D) None of them

20. Who discovered left hand rule? ***(K.B)***
(A) Einstein (B) Simon
(C) Fleming (D) Faraday

15.3 TURNING EFFECT ON CURRENT CARRYING COIL IN MAGNETIC FIELD
15.4 D.C MOTOR

LONG QUESTIONS

Q.1 State that a current carrying coil in a magnetic field experiences a torque.

(K.B+U.B+A.B)

(MTN 2016, DGK 2016) (Review Ex. 15.5)

Ans: **CURRENT – CARRYING COIL IN A MAGNETIC FIELD**

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

Explanation:

Consider a rectangular coil of wire with sides PQ and RS, lying perpendicular to the field, placed between the two poles of a permanent magnet.

Now if the ends of the coil are connected with the positive and negative terminals of a battery, a 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.

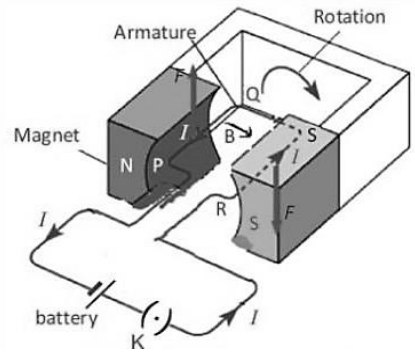


Figure: A Current- Carrying Coil in a Magnetic Field

Now apply Fleming's left hand rule to each side of the coil. We can see the PQ 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 also increased. This is the working principle of electric motors.

Q.2 What is electric motor? Explain its construction and working principle.

(K.B+A.B+U.B)

(LHR 2016, DGK 2016, BHP 2016) (Review Ex. 15.6)

Ans: **ELECTRIC MOTOR**

"It is an electrical apparatus (device) that converts electrical energy into rotational kinetic energy**"**.

Working Principle:

When a current-carrying coil is placed in magnetic field, it experiences a couple due to which the coil begins to rotate. A D.C motor operates on this principle.

Construction of D.C Motor:

D.C motor consists of a rectangular coil PQSR mounted on a shaft or axle. Coil is placed in a field of permanent magnet or in a field which is produced by an electromagnet,

called a field coil. There are two carbon brushes which are usually pieces of graphite, these brushes are made the contact with copper ring. This ring is split into two halves, called a split ring commentators.

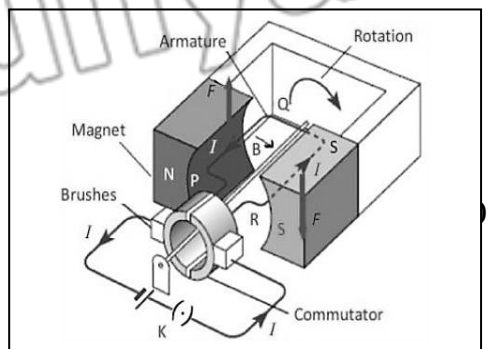


Figure: Working Principle of D.C Motor

Working of D.C Motor:

When the coil of the motor is connected to the battery, the current starts flowing through it. 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 of the forces are still up and down and hence balanced.

Function of Commutator:

The coil can be rotate continuously by reversing the direction of the current just as the coil reaches its vertical position. This reversal of current will allow the coil to rotate continuously. To reverse direction of 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. Brushes, which are usually pieces of graphite, make contact with the commutator and allow current to flow into the loop. As the loop rotates, so does the commutator. The split ring is arranged so that each half of the commutator changes brushes just as the coil reaches the vertical position. Changing brushes reverse the current in the loop.

As a result, the direction of the force on each side of the coil is reversed and it continues to rotate. This process repeats at each half-turn, causing coil to rotate in the magnetic field continuously. The result is an electric motor, which is a device that converts electric energy into rotational kinetic energy.

In a practical electric motor the coil, called a 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.

Factors Increasing Force on Armature:

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

- Increasing the number of turns on the coil
- Increasing the current in the coil
- Increasing the strength of the magnetic field
- Increasing the area of the coil

15.3, 15.4 SHORT QUESTIONS

Q.1 Which device converts electrical energy into mechanical energy and what is its working principle? ***(K.B)*** **(2017 LHR)**

OR What is D.C. Motor? ***(K.B)***

OR Define Electric Motor. ***(K.B)*** **(RWP 2016)**

Ans: ***Given on Page # 282***

Q.2 How can we make the coil of D.C motor rotate continuously? ***(K.B)***

Ans:

CONTINUOUS ROTATION OF COIL

The coil can be rotate continuously by reversing the direction of the current just as the coil reaches its vertical position. This reversal of current will allow the coil to rotate continuously. To reverse direction of 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. Brushes, which are usually pieces of graphite, make contact with the commutator and allow current to flow into the loop. As the loop rotates, so does the commutator. The split ring is arranged so that each half of the commutator changes brushes just as the coil reaches the vertical position. Changing brushes reverse the current in the loop. As a result, the direction of the force on each side of the coil is reversed and it continues to rotate.

Q.3 What is the function of split rings in D.C. motor? ***(K.B+A.B+U.B)*** **(RWP 2017)**

Ans:

FUNCTION OF SPLIT RINGS

The functions of split rings in D.C. motor are as follows:

- Split rings connect the coil to the battery through carbon brushes.
- When coil rotates between the pole pieces of a magnet, split rings keep the current in the same direction in the rotating coil.
- Split rings change the direction of current in the sides of coil after every half cycle, so the direction of force is changed after every half cycle.

Q.4 How the total force acting on the armature can be increased? ***(K.B)***

Ans: ***Given on Page # 283***

Q.5 What is the function of carbon brushes in D.C. motor? ***(K.B+A.B)***

Ans:

FUNCTION OF CARBON BRUSHES IN D.C. MOTOR

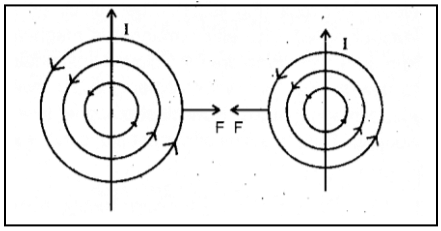
The function of carbon brushes in D.C. motor are:

Two carbon brushes are used to press slightly against the split rings by means of springs and give continuous passage of current to the coil.

Q.6 Suppose the direction of current passing through two straight wires is same. Draw the pattern of magnetic field of current due to each wire. Would the wires attract or repel each other? ***(K.B)*** **(Activity Page 123)**

Ans:

When current flows through wires in the upward direction, the magnetic field lines around each wire are in the form of concentric circles as shown in figure.



The magnetic field lines of two wires cancel the effect of each the in the space between them. Hence, the two wires attract each other due to weak magnetic field between them and the stronger magnetic field on the other sides of the wires.

Q.7 How ATM card works? ***(U.B)*** **(Do you know Pg. # 124)**

Ans: **WORKING OF ATM CARDS**

Bank credit card have a magnet strips engraved on them. On this strip account information of the user are stored which are read by the ATM machine.

Q.8 What is connection of magnetic and electric field lines? ***(U.B)*** **(Connection Pg. # 125)**

Ans: **MAGNETIC AND ELECTRIC FIELD LINES**

Magnetic field lines help us to visualize the magnitude and direction of the magnetic field vectors, just as electric field lines do for the magnitude and direction of E.

15.3, 15.4 MULTIPLE CHOICE QUESTIONS

1. Force on current carrying conductor in a magnetic field is found by: ***(K.B)***

(A) Right Hand Rule (B) Left Hand Rule
(C) Both a & b (D) None of them

2. A device which is used to convert electrical energy into rotational kinetic energy: ***(K.B)***

(A) Transformer (B) A.C Generator
(C) D.C Motor (D) All of them

3. Which part of DC motor reverses the direction of current through coil every half cycle? ***(K.B)*** **(SGD-G2),(RWP-G2)-2017**

(A) Armature (B) Commutator
(C) Brushes (D) Split rings

4. In D.C motor coil can rotate in magnetic field by an angle of: ***(K.B)*** **(DGK-G1)-2017**

(A) 30° (B) 45°
(C) 60° (D) 90°

5. Which device is based on the principle of electromagnetism? ***(K.B)***

(A) Mechanical energy into electrical energy (B) Mechanical energy into chemical energy
(C) Electrical energy into mechanical energy (D) Electrical energy into chemical energy

15.5 ELECTROMAGNETIC INDUCTION, 15.6 DIRECTION OF INDUCED E.M.F – LENZ'S LAW 15.7 A.C GENERATOR

LONG QUESTIONS

Q.1 Describe by an experiment to demonstrate that changing magnetic field can induced e.m.f in a circuit? ***(K.B, U.B, A.B)*** **(Review Ex. 15.7)**

OR What is electromagnetic induction? Explain with experiment that a changing magnetic field can induce an e.m.f in circuit?

Ans: **ELECTROMAGNETIC INDUCTION**

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

Explanation:

Hans Christian Oersted and Ampere discovered that an electric current through a conductor produces a magnetic field around it. Michael Faraday thought that the reverse must also be true; that a magnetic field must produce an electric current. Faraday found that he could induced electric current by moving the wire through the magnetic field. In the same year Joseph Henry also showed that a changing magnetic field could produce electric current.

Strength of Magnetic Field:

The number of magnetic lines of force passing through any surface is known as strength of magnetic field.

How e.m.f. is Induce in the Coil?

Strength of the magnetic field is maximum when the surface is held perpendicular to the magnetic lines of force.

Strength of the field is minimum when surface is held parallel to the magnetic lines of force.

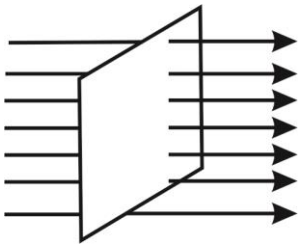


Figure: Maximum Strength of Magnetic Field

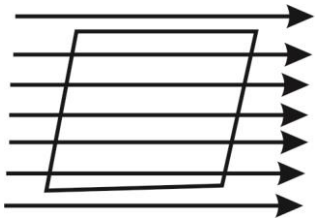


Figure: Minimum Strength of Magnetic Field

Magnetic Field of a Bar Magnet through Coil:

In case of a bar magnet the lines of force are emerging from North Pole of a magnet. If we place a coil in the magnetic field of a bar magnet, some of the magnetic lines of force will pass through it.

When the Coil is Far Away from the Magnet:

If the coil is far away from the magnet, only a few lines of force will pass through the coil.

When the Coil is Closed to the Magnet:

If the coil is close to the magnet, a large number of lines of force will pass through it, in this way 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 and e.m.f in the coil.

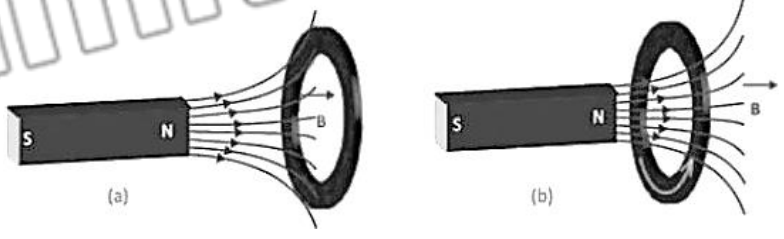


Figure: Variation of Magnetic Field Lines of Force through a Coil Placed at Different Distances From the Magnet

Note: This is the basic principle of production of electricity and working of A.C generator.

Experiment:

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-shaped magnet. Galvanometer shows no deflection and hence there is no current. Now move the wire downward through the field, current is induced in one direction as shown by the deflection of the galvanometer. Now move the wire upward though the field, current is induced in the opposite direction.

It implies that an electric current is generated in a wire only when the wire cuts magnetic field lines. This induced current is generated by induced e.m.f. in the circuit. Faraday found that to generate current, either the conductor must move through a magnetic field or a magnetic field must change across the conductor.

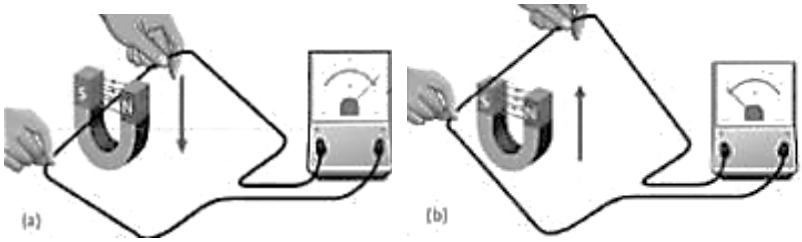


Figure: **Demonstration of Electromagnetic Induction by the Movement of a Wire Loop in the Manget Field**

Conclusion:

It is concluded that an electric current is generated in a wire only when the wire cuts magnetic field lines. This induced current is generate by the induced e.m.f in the circuit.

Q.2 State Faraday's law of electromagnetic induction. Explain with experiment how current is induced in a solenoid? Write factors. ***(K.B+A.B+U.B)***

Ans:

FARADAY'S LAW

Statement:

"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."

Induce Current in Solenoid:

Faraday perform experiments in which a current is induced by moving a magnetic into the solenoid or out of the solenoid.

When the magnet is stationary, no current is induced. When the magnet is moved towards the solenoid, the needle of galvanometer deflects towards right, indicating that current is being induced in the solenoid.

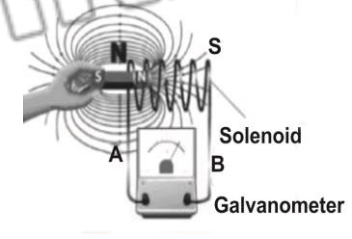


Figure: **Magnet Move Towards Stationary Solenoid**

When the magnet is pulled away from the solenoid, the galvanometer deflects towards left, indicating that the induced current in the solenoid is in the opposite direction.

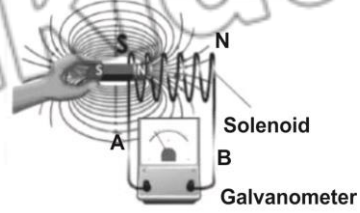


Figure: **Magnet Move Away From Stationary Solenoid**

Conclusion:

From the experiments it is concluded that an e.m.f in induced in the coil when there is a relative motion between the coil and the magnet.

Electromagnetic Induction:

The phenomenon in which an e.m.f is induced due to the relative motion between the coil and the magnet is called electromagnetic induction.

Factors Affecting Induced e.m.f:

The magnitude of induced e.m.f in a circuit depends on the following factors:

- Speed of relative motion of coil and magnet
- Number of turns of coil.

Q.3 State Lenz's law? Describe the direction of an induced e.m.f in a circuit. How does this phenomenon relate to conservation of energy? ***(K.B+U.B+A.B)*** **(Review Ex. 15.9)**

Ans: **LENZ'S LAW**

Statement:

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

Direction of Induced e.m.f:

Lenz devised a rule to find out the direction of a current induced in a circuit.

Experiment:

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.

The direction of the induced current in the solenoid by the induced e.m.f will be such that it will repel the north pole of the magnet. This is only possible if the left end of the solenoid becomes north pole. Hence according to right hand grip rule the direction of the induced current in the solenoid will the anticlockwise.

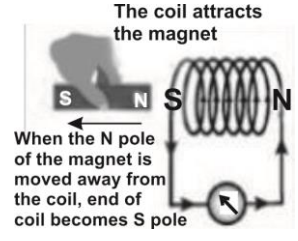


Figure: **Direction of Induced Current When Magnet is Moved Toward the Coil**

Similarly, when we move the north pole of the magnet away from the solenoid the direction of the induced current will be clockwise. In this case left end of solenoid becomes south pole.

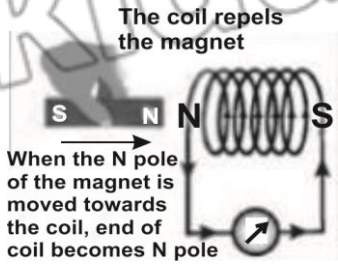


Figure: **Direction of Induced Current When Magnet is Moved Away From the Coil**

Induce e.m.f and Conservation of Energy:

If we apply the law of conservation of energy to electromagnetic induction, we realize that the electrical energy induce in a conductor comes from the kinetic energy of the moving magnet. We do some work on the magnet to bring it close to the solenoid. This work consequently appears as electrical energy is the conductor. Thus 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 law of conservation of energy.

Q.4 What is A.C. Generator? How is it constructed? How current is induced in it? ***(K.B+U.B+A.B)***
(LHR 2013, SGD 2016) , (Review Ex. 15.10)

Ans:

A.C GENERATOR

Definition:

"A device which generates an alternating e.m.f is called A.C. generator**"**.

A generator converts mechanical energy into electrical energy.

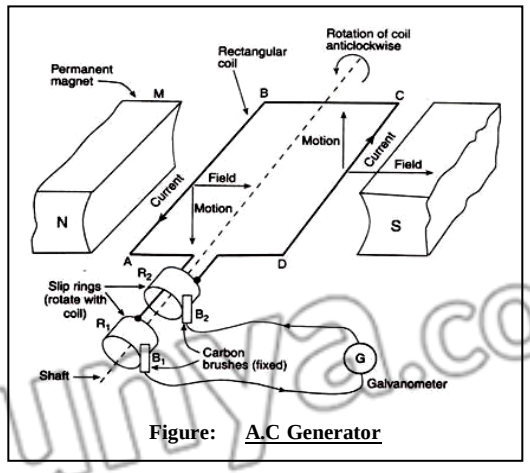


Figure: **A.C Generator**

Working Principle:

The number of lines of magnetic force passing through the coil will be maximum when the plane of the coil is perpendicular to the lines of magnetic force. The number of lines of magnetic force will be zero when plane of the coil is parallel to the lines of force. Thus, 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. This is the basic principle on which an A.C generator works.

Construction and Working:

An A.C generator consists of a rectangular coil and magnet, which is rotated between the poles of a permanent magnet. Both the ends of the coil are soldered to the two slip rings fixed on the arm of the coil as shown in figure.

Two carbon brushes are kept in contact with these slip rings with the help of two springs. Current is drawn from the coil through these brushes.

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 an e.m.f will be produced. The e.m.f. developed by the generator depends on 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:

When a generator is connected in a closed circuit, the induced e.m.f generates an electric current. As the loop rotates the strength and the direction of the current changes.

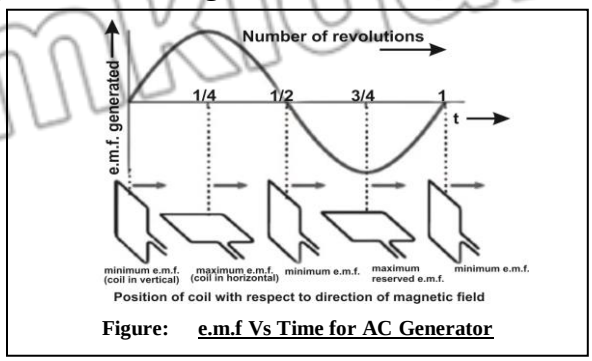


Figure: e.m.f Vs Time for AC Generator

When the plane of coil is perpendicular to field, the number of lines of magnetic force passing the trough it is maximum. But the change in the number of line through the coil is minimum. So e.m.f. induced is minimum.

The current is minimum when the plane of the loop is perpendicular to the magnetic field; that is, when the loop is in the vertical position. As the loop rotates from the vertical to the horizontal position, it cuts through large magnetic field lines per unit of time, thus the e.m.f and the current increase. When the loop is horizontal the plane of the loop becomes parallel to the field, the e.m.f and the current reaches its maximum values. As the loop continues to turn, the segment that was moving up begins to move down and reverses the direction of the e.m.f and the current in the loop. This change in direction takes place each time the loop turns through 180^o. 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.

15.5, 15.6, 15.7 SHORT QUESTION

Q.1 Define electromagnetic induction. ***(K.B)***

(LHR 2016, FSD 2016, SHW 2016, DGK 2016, SGD 2017, RWP 2017)

Ans: **ELECTROMAGNETIC INDUCTION**

Definition:

"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."

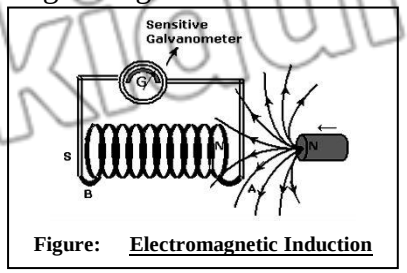


Figure: Electromagnetic Induction

Q.2 State Faraday law of Electromagnetic Induction. ***(K.B)*** **(GRW 2013, LHR 2013, SHW 2016)**

Ans: ***Given on Page # 287***

Q.3 Define A.C. Generator. ***(K.B)***

Ans: ***Given on Page # 289***

Q.4 Write down the principle of A.C. generator. ***(U.B)*** **(GRW 2015, LHR 2015)**

Ans: **PRINCIPLE OF A.C. GENERATOR**

Principle:

The number of lines of magnetic force passing through the coil will be maximum when the plane of the coil is perpendicular to the lines of magnetic force. The number of lines of magnetic force will be zero when plane of the coil is parallel to the lines of force. Thus, 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. This is the basic principle on which an A.C generator works.

Q.5 What is meant by strength of magnetic field? When it is maximum and minimum? ***(K.B)***

Ans: ***Given on Page # 286***

Q.6 Is it possible that a constant current flowing in a coil produces an induced current in another coil? ***(K.B)***

Ans: **PRODUCTION OF INCDUCED CURRENT**

No, a constant current flowing in one coil cannot produce induced current in another coil. In order to produce induced current in another coil, the current in first coil must be changing continuously so that magnetic flux may pass through another coil.

Q.7 State Lenz's law? ***(K.B)*** **(LHR 2014, 2017, SGD 2017, RWP 2017, SHW 2016)**

Ans: ***Given on Page # 288***

Q.8 Prove that Lenz law is a manifestation of the law of conservation of energy. ***(K.B+U.B)***

OR How does Induce e.m.f relate to conservation of energy?

Ans: **INDUCE E.M.F AND CONSERVATION OF ENERGY**

If we apply the law of conservation of energy to electromagnetic induction, we realize that the electrical energy induce in a conductor appears from the kinetic energy of the moving magnet. We do some work on the magnet to bring it close to the solenoid. This work consequently appears as electrical energy is the conductor. Thus 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.9 What is the contribution of Joseph Henry in electromagnetic induction? ***(K.B)***

Ans: **PHYSICS FACT** **(Text book Info. Pg. # 126)**

It is said, Joseph Henry (1797-1878) had observed an induced current before Faraday, but Faraday published his results first and investigated the subject in more detail.

Q.10 Differentiation between A.C Generator and D.C Generator. ***(Conceptual Base)***

Ans: **DIFFERENTIATION**

A.C Generator	D.C Generator
• A device which produces or generates an alternating emf is called A.C. generator. • Slip rings are used to produce alternating current.	• A device which produces or generates an direct emf is called D.C. generator. • Commutators are used in D.C generator to produce direct current.

Q.11 What was the contribution of Michael Faraday? ***(K.B)***

Ans: **MICHAEL FARADAY** **(Text book Info. Pg. # 129)**

Michael Faraday was a British chemist and physicist. He discovered the principle of electromagnetic induction and the laws of electrolysis etc.

Figure: Michael Faraday

Q.12 How electricity is produce by electromagnetic induction? ***(K.B)***

Ans: **PRODUCTION OF ELECTRICITY**

If we place a coil in the magnetic field of a bar magnet, some of the magnetic lines of force will pass through it.

When the Coil is Far Away From the Magnet:

If the coil is far away from the magnet, only a few lines of force will pass through the coil.

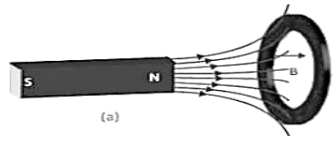


Figure: Less Line of Force

When the Coil is Closed to the Magnet:

If the coil is close to the magnet, a large number of lines of force will pass through it, In this way 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 and e.m.f in the coil as shown in fig b.

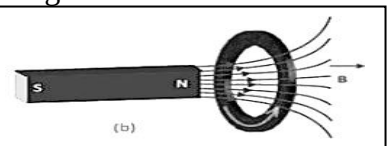


Figure: More Line of Force

Note: This is the basic principle of production of electricity and working of A.C Generator.

Q.13 What factors affect induced emf? ***(K.B)*** **(RWP 2017,BWP 2016), (Review Ex. 15.8)**

OR What are the factors which affect the magnitude of e.m.f. induced in a circuit by a changing magnetic field?

Ans: **FACTORS AFFECTING INDUCED E.M.F**

The magnitude of induced e.m.f in a circuit depends on the following factors:

- Speed of relative motion of coil and magnet
- Number of turns of coil.
- Strength of magnet

Q.14 Fleming's right-hand rule. ***(Conceptual Base)***

Ans: "Stretch the thumb, forefinger and the middle finger of the right hand mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field, the second finger in the direction of induced current, then the thumb would indicate the direction of motion of conductor.

Q.15 Define Eddy Currents. ***(Conceptual Base)***

Ans: If the aluminium disc below is set spinning, it may be many seconds before frictional force finally brings it to rest. However, if it spinning between the poles of a magnet, it stops almost immediately. This is because the disc is a good conductor and currents are induced in it as it moves through the magnetic field. These are called eddy currents. They produce a magnetic field which, by Lenz's law, opposes the motion of the disc. Eddy currents occur wherever pieces of metal are in a changing magnetic field – for example, in the core of a transformer.

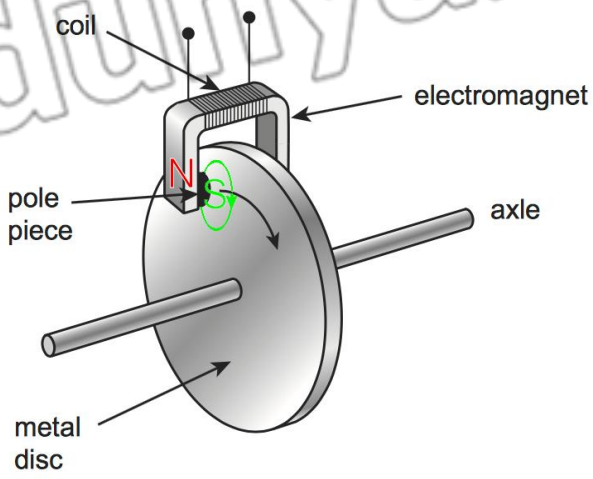


Fig. Metal disc rotating in magnet

Q.16 How metal detector work? ***(Conceptual Base)***

Ans: Metal detector rely on eddy currents. Typically, a pulse of current through a flat coil produces a changing magnetic field. This induces eddy currents in any metal object underneath. The eddy currents give off their own changing field which induces a second pulse in the oil. This is detected electronically.

Fig. Metal Detector

Q.17 Which device convert mechanical energy into electrical energy in hydroelectric dam? ***(K.B)*** **(Do you know Pg. # 129)**

Ans:

GENERATOR

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

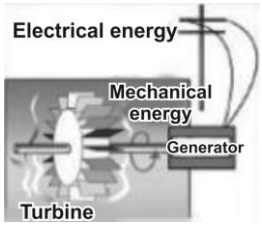


Figure: Generator Inside Hydroelectric Dam

15.5, 15.6, 15.7 MULTIPLE CHOICE QUESTIONS

1. Electromagnetic induction was discovered by: *(K.B)* **(GRW 2013)**
(A) Newton (B) Galileo
(C) Einstein (D) Faraday

2. Who found the direction of induced e.m.f first time? *(K.B)*
(A) Faraday (B) Lenz
(C) Henry (D) Bohr

3. The value of induced emf is directly proportional to the rate of change of: *(U.B+A.B)*
(A) Current (B) Resistance
(C) Potential (D) Flux

4. The number of magnetic lines of force passing through any surface: *(K.B)*
(A) emf (B) Current
(C) Flux (D) Resistance

5. The magnitude of induced emf depends upon the speed of: *(K.B)*
(A) Magnet (B) Coil
(C) Current (D) relative Motion

6. A device used to convert mechanical energy into electrical energy: *(K.B)*
(A) Transformer (B) A.C Generator
(C) D.C Motor (D) All of them

7. A generator works on the principle of: *(K.B)*
(A) Electromagnetic induction (B) Electrostatic induction
(C) Both of them (D) None of these

8. When a straight current carrying conductor is placed in a magnetic field at right angle to it, the direction of force acting on conductor is: *(U.B)*
(A) Same as the direction of field (B) Opposite to the direction of the field
(C) Makes an angle of 45^0 with the current (D) At right angle to both the field and current

9. Walk through metal detector are installed at airport and other places for: *(K.B)*
(A) Security purpose (B) Decoration
(C) Useless purpose (D) All of these

10. According to Faraday's law of induced emf is ____proportional to change in flux. *(U.B+A.B)*
(A) Directly (B) Inversely
(C) Equal (D) Opposite

11. Who discovered the phenomenon of electromagnetic induction? *(K.B)* **(GRW 2013)**
(A) Ohm (B) Coulomb
(C) Faraday (D) None of these

12. Micheal Faraday belonged to _____. **(LHR 2015)**
(A) Russia (B) K.S.A
(C) U.S.A (D) British

13. Law of electromagnetic induction and electrolysis were presented by: *(K.B)* **(GRW 2015)**
(A) Simon ohm (B) Jeorge Coulomb
(C) Newton (D) Michel Faraday

14. Which thing work on the phenomenon of electromagnetic induction in hydroelectric power plant? *(U.B)*
(A) Motor (B) Generator
(C) Galvanic cell (D) Volatic cell

15. Magnetic field of coil Is identical to field of _____ magnet. *(K.B)* **(Do you know Pg. # 131)**
(A) Bar (B) Disk Shaped
(C) Horse shoe (D) none

16. A generator is a ____ with its inputs and outputs reversed. *(K.B)*
(A) Transformer (B) D.C Motor
(C) Relay (D) Capacitor

15.8 MUTUAL INDUCTION
15.9 TRANSFORMER
15.10 HIGH VOLTAGE TRANSMISSION

LONG QUESTIONS

Q.1 What is meant by mutual induction? *(K.B+U.B+A.B)*
OR What do you understand by the term mutual induction?
(SGD 2016, MTN 2016), (Review Ex. 15.11)

Ans: **MUTUAL INDUCTION**

"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 and B placed closed to each other. 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.

Mechanism:

We can explain these observation using Faraday's law of electromagnetic induction. When the switch of coil A is closed, a current begins to flow in the coil due to which magnetic field is developed across the coil. Some of the magnetic lines of forces of this field start passing through the coil B. 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. When current in the coil A becomes steady, number of magnetic lines of force across the coil A also becomes constant. Therefore there is no more change in number of magnetic lines of force through the coil B due to which induced current in coil B reduces to zero.

Similarly when the switch of the coil A is opened, the flow of current through it stops and 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.

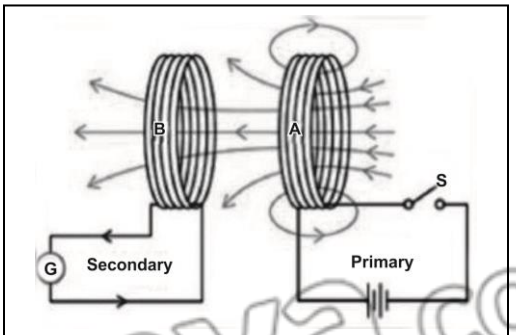


Figure: Mutual Induction

Q.2 What is transformer? Explain its construction, working principle and types. *(K.B+U.B+A.B)*
OR What is a transformer? Explain the working of a transformer in connection with mutual induction.
(LHR 2013, SHW 2016, MTN 2016), (Review Ex. 15.12)

Ans: **TRANSFORMER**

"Transformer is an electrical device which is used to increase or decrease the value of A.C voltage**"**.

Construction:

A transformer has two coils, electrically insulated from each other, but wound around the same iron core. One coil is called the primary coil the other coil is called the secondary coil. Number of turns on the primary and the secondary coils are represented by N_P and N_S respectively.

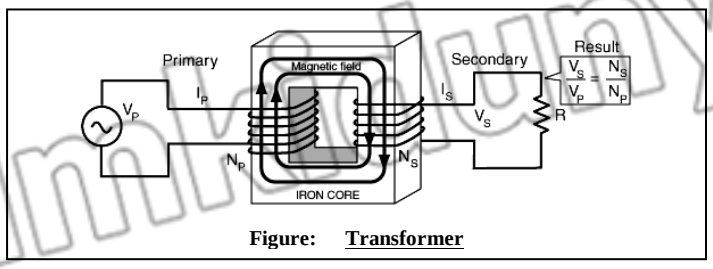


Figure: Transformer

WORKING PRINCIPLE

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 alternating e.m.f. This effect is called mutual inductance. Hence, mutual inductance is working principle of transformer.

Voltages and Number of Turns of Coil:

The e.m.f induced in the secondary coil, called the secondary voltage $\mathbf{V_S}$ is proportional to the primary voltage $\mathbf{V_p}$. The secondary voltage also depends 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 expressions, $\frac{\mathbf{V_S}}{\mathbf{V_P}} = \frac{\mathbf{N_S}}{\mathbf{N_P}}$

Types:

There are two types of transformer

- Step – up transformer
- Step-down transformer

Step – up transformer:

If **Ns>Np**, then secondary voltage is larger than the primary voltage, then the transformer is called a step-up transformer.

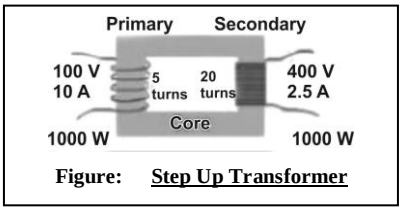


Figure: Step Up Transformer

Step-down transformer:

If **Np > Ns** then the secondary voltage is smaller than the primary voltage, then transformer is called a step-down transformer.

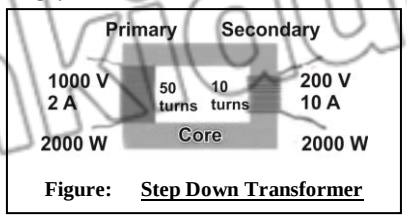


Figure: Step Down Transformer

An Ideal Transformer :

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

$$\mathbf{P_P = P_S}$$

$$\mathbf{V_P I_P = V_S I_S}$$

Uses of Transformer:

Transformer are used to increase or decrease AC voltages. Usage of transformers is common because they change voltages with relatively little loss of energy. In fact, many of the devices in our homes, such as game systems, printers and stereos use transformers for their working.

Q.3 How high voltage transmission reach from power station to consumer?(*U.B+A.B*)
OR Why alternating voltage is stepped up at the generating station?

Ans: **HIGH VOLTAGE TRANSMISSION**

Dissipation of Heat in Transmission:

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 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.

Stepping Down Voltage:

High voltages are transmitted to the main sub-station. This voltage is stepped down and is transmitted to the switching transformer station or the city sub-station. At the city sub-station it is further stepped down to 20V and supplied to the consumer.

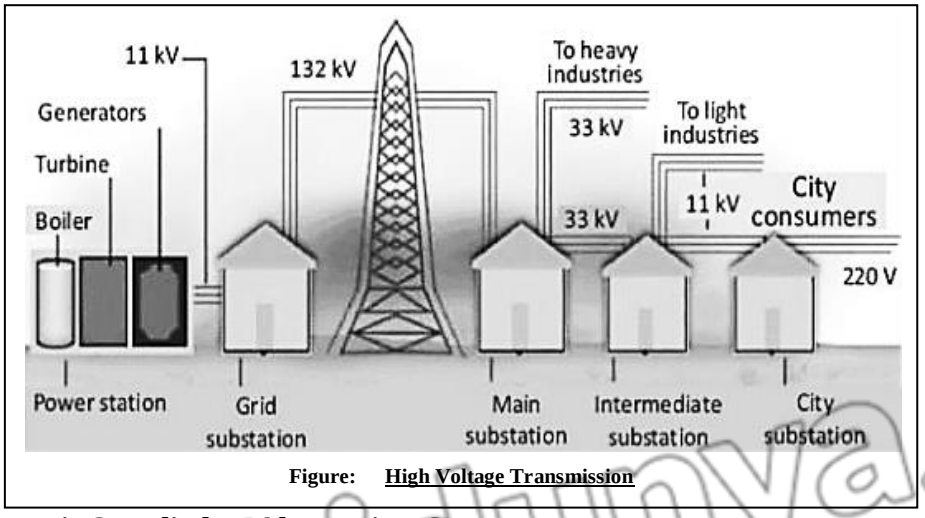


Figure: High Voltage Transmission

Main Power is Supplied as Alternating Current:

Transformers play an essential part in power distribution. Transformer work only with AC. This is one reason why mains power is supplied as alternating current.

Q.4 What is an electromagnetic? Explain its uses giving one practical example. *(A.B)*

Ans: **ELECTROMAGNET**

Definition:

"Magnetic effect of current is called electromagnet**"**.

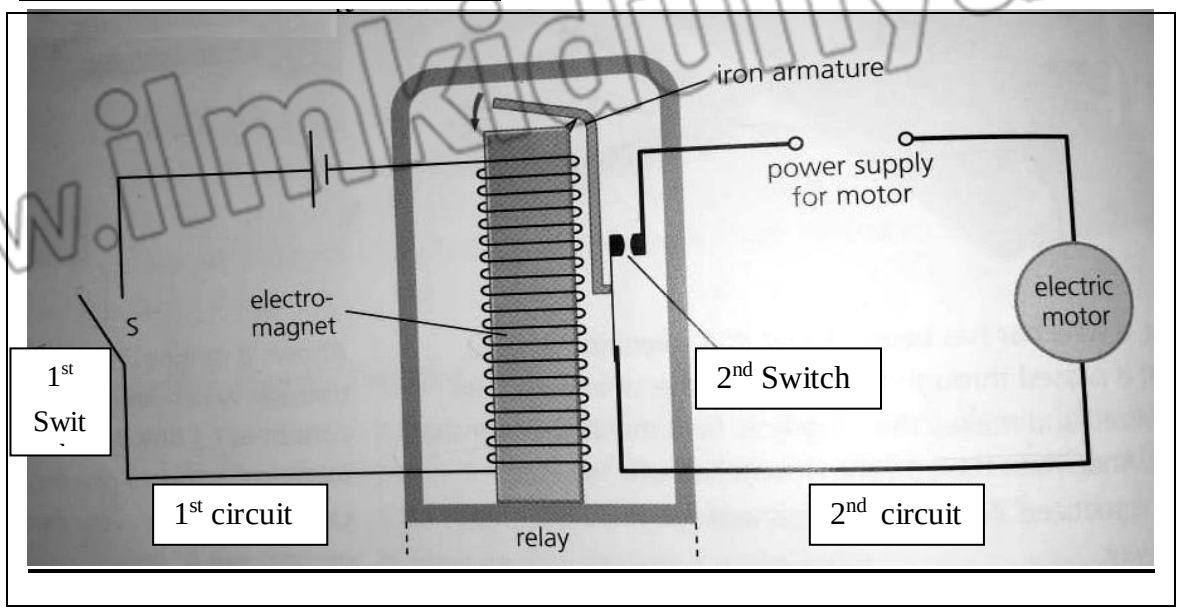
Application / Uses:

This affect is used in many devices like relay, electric bell etc. soft iron can easily magnetized and demagnetized.

Relay Circuit: **(GRW 2013)**

"A relay is an electrical switch that opens and closes under the control of another electrical circuit**"**. The relay is used to control a large current with the help of small current.

Working Principle of Relay Circuit:



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 second circuit when the first switch is opened 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.

Examples of Magnetic Effect of an Electric Current:

- Loud Speaker
- Circuit breaker
- Door latches

15.8, 15.9, 15.10 SHORT QUESTIONS

Q.1 Define mutual induction. ***(K.B)***
(GRW 2013, LHR 2013, FSD 2016, 2017, SGD 2016, 2017, MTN 2016)

Ans: ***Given on Page # 295***

Q.2 Define self-Induction. ***(K.B)***

Ans:

SELF INDUCTION

Definition:

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

Q.3 Define transformer. ***(K.B)*** **(GRW 2014)**

Ans: ***Given on Page # 295***

Q.4 What do you know about primary coil and secondary coil? ***(K.B)***

OR How many coils are used in transformer? ***(K.B)*** **(LHR 2014, SHW 2017, RWP 2017)**

Ans: ***Given on Page # 296***

Q.5 Define step down transformer and step up transformer. ***(K.B)***
(LHR 2015, SDG 2016, 2017, FSD 2017, MTN 2016, BWP 2017)

Ans: ***Given on Page # 296***

Q.6 What is the function of core in the transformer? ***(K.B)***

Ans:

FUNCTION OF CORE OF TRANSFORMER

The functions of core in transformer are:

- The iron core enhances the magnetic flux produced in the primary coil.
- The magnetic flux linked to the secondary coil through iron core.

Q.7 Why alternating voltage is stepped up at the generating station? ***(K.B)*** **(Review Ex. 15.13)**

OR The voltage chosen for the transmission of electrical power over large distance is electrical power is transmitted at high voltage.

Ans: **REASON OF STEPPING UP**

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^2 Rt. Hence by reducing the current 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.

Q.8 How voltages are stepped down? **(Review Ex. 15.14)**

OR Why is the voltage used for the domestic supply much lower than the voltage at which the power is transmitted? ***(K.B+A.B)***

Ans: **REASON OF STEPPING DOWN**

High voltages are transmitted to the main sub-station. This voltage is stepped down and is transmitted to the switching transformer station or the city sub-station. At the city sub-station it is further stepped down to 220V and supplied to the consumer.

Q.9 Why mains power is supplied as alternating current? ***(K.B)***

Ans: **REASON OF MAINS ALTERNATING VOLTAGE**

Transformers play an essential part in power distribution. Transformer work only with AC. This is only reason why mains power is supplied as alternating current.

Q.10 What is relay circuit? ***(K.B)***

Ans: ***Given on Page # 297***

Q.11 Explain working principle of relay circuit. ***(K.B+U.B)***

Ans: ***Given on Page # 297***

Q.12 Define ideal transformer. ***(K.B)***

Ans: ***Given on Page # 296***

Q.13 What is working principle of transformer? ***(K.B)***

Ans: ***Given on Page # 296***

Q.14 Can a transformer work on D.C? ***(K.B+U.B)***

As the transformer work on the principle of mutual induction and this phenomena occurs only in the case of A.C. That is why transformer cannot work on D.C.

Q.15 What are uses of transformer? ***(A.B)***

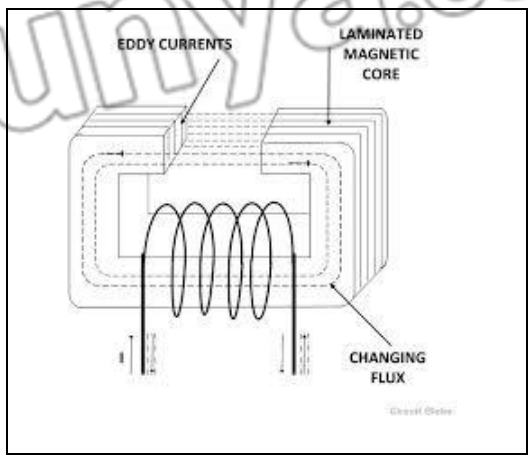
Ans: **USES OF TRANSFORMER**

The uses of transformer are:

- Transformer are used to increase or decrease AC voltages.
- Usage of transformers is common because they change voltages with relatively little loss of energy.
- Many of the devices in our homes, such as game systems, printers and stereos use transformers inside their casings or as part of their connecting cords.

Q.16 Why the core of transformer is laminated (layered)? ***(Conceptual Base)***

Ans: The core is itself a conductor, so the changing magnetic field induces currents in it. These circulating eddy currents have a heating effect. To reduce them, the core is laminated (layered): it is made from thin, insulated sheets of iron or Mumetal, rather than a solid block.



15.8, 15.9, 15.10 MULTIPLE CHOICE QUESTIONS

1. If the Current is induced in a circuit due to change of current in an other circuit, this process is known as: ***(K.B)***
(A) Electrostatic induction (B) Mutual induction
(C) Self-induction (D) None of them

2. The coil of transformer in which change in current produces induced current in another coil is known as: ***(K.B)***
(A) Primary (B) Secondary
(C) Solenoid (D) All of them

3. A coil in which current is induced is known as: ***(K.B)***
(A) Primary (B) Secondary
(C) Solenoid (D) All of them

4. If the current through a coil or a circuit changes and this change induces an emf in the circuit itself, this process is known as: ***(K.B)***
(A) Electrostatic induction (B) Mutual induction
(C) Self-induction (D) None of them

5. An electrical device which is used to increase or decrease the value of alternating voltage: ***(A.B)***
(A) Transformer (B) A.C generator
(C) D.C motor (D) All of them

6. The coil which is connected to the alternating voltage whose value is to be altered is known as: ***(K.B)***
(A) Primary coil (B) Secondary coil
(C) Solenoid (D) All of them

7. The Coil of transformer in which alternating voltage is induced is known as: ***(K.B)***
(A) Primary coil (B) Secondary coil
(C) Solenoid (D) All of them

8. Transformer works on the principle of: ***(K.B)***
(A) Electrostatic induction (B) Mutual induction
(C) Self Induction (D) All of them

9. Type of transformer which is used to increase the value of alternating voltage: ***(A.B)***
(A) Step up (B) Step down
(C) Step forward (D) Step back

10. Type of transformer which is used to decrease the value of alternating voltage: ***(A.B)***
(A) Step up (B) Step down
(C) Step forward (D) Step back

11. A transformer has 100 turns in primary and 500 turns in the secondary. If 6 Volts D.C is applied across its primary, the voltage induced across its secondary would be: ***(A.B)***
(A) 0V (B) 30V
(C) 45V (D) 60V

12. A practical application of mutual induction is: ***(A.B)***
(A) Transformer (B) Electrical motor
(C) Generator (D) Diode

13. Number of turns on the primary coil is represented as: ***(K.B)***
(A) N_s (B) N_p
(C) N_s (D) N_a

14. Number of turns on secondary coil is: ***(K.B)***
(A) N_s (B) N_d
(C) N_a (D) N_p

15. In step-up transformer: ***(U.B)***
(A) $V_s > N_s$ (B) $U_p > V_p$
(C) $V_s > V_p$ (D) $V_s > N_s$

16. Transformer is called step-down when: ***(U.B)***
(A) $V_s > V_p$ (B) $V_s > N_s$
(C) $V_p < V_s$ (D) $V_s < V_p$

17. Electric power is usually generated at places which are far from the places where it is: ***(K.B)***
(A) Consumed (B) Produced
(C) Not needed (D) Developed

18. Voltage of current supplied to consumers is: ***(K.B)***
(A) 230 V (B) 240 V
(C) 210 V (D) 220 V

19. Electromagnet is used in device: ***(A.B)***
(A) Electric bell (B) Relay
(C) Both A and B (D) Thermometer

20. Which is an electric switch that opens and closes under the control of another electrical circuit? ***(K.B)***
(A) Relay (B) Electric bell
(C) Electric circuit (D) A.C Generator

21. Step down transformer: ***(K.B)*** **(LHR 2016)**
(A) Decreases input current (B) Decreases input voltage
(C) Has more turns in secondary coil (D) Has less turns in primary coil

22. Transformer is used to: ***(A.B)*** **(GRW 2016)**
(A) Increase voltage (B) Decrease voltage
(C) Both a and b (D) None of these

23. Types of transformer are: ***(K.B)*** **(GRW 2013)**
(A) 1 (B) 2
(C) 3 (D) 4

24. Transformers are used to: ***(A.B)*** **(LHR 2016)**

(A) Increase voltage (B) Increase resistance
(C) Both a and b (D) None of these

25. Transformer is used to change the value of: ***(A.B)*** **(LHR 2017)**

(A) Voltage (B) Power
(C) Energy (D) Charge

EXAMPLE 15.1 *(U.B+A.B)*

If a transformer is used to supply voltage to a 12V model train which draws a current of 0.8 A. Calculate the current in the primary if the voltage of of the A.C. Source is 240 V.

Given Data

Primary voltage = V_p= 240 V
Secondary voltage = V_s = 12 V
Secondary current = I_s= 0.8 A

To Find:

Primary current = I_p = ?

Formula:

According to law of conservation of energy,

Input Power of the primary = Output power of the secondary

i.e., $I_pV_p = I_sV_s$

Calculation:

$$I_P = \frac{I_S v_S}{V_P}$$

$$I_P = \frac{(12\ V)(0.8\ A)}{240\ V} = 0.04A$$

Result:

The primary current to the transformer is 0.04 A.

MCQ'S ANSWER KEY (TOPIC WISE)

15.1 MAGNETIC EFFECTS OF A STEADY CURRENT

15.2 FORCE ON A CURRENT – CARRYING CONDUCTOR PLACED IN MAGNETIC FIELD

1	2	3	4	5	6	7	8	9	10	11	12
C	C	B	B	C	B	A	B	C	A	A	B

13	14	15	16	17	18	19	20	21
A	B	B	B	C	A	A	B	C

15.3 TURNING EFFECT ON CURRENT CARRYING COIL IN MAGNETIC FIELD

15.4 D.C MOTOR

1	2	3	4	5
B	C	D	D	A

15.5 ELECTROMAGNETIC INDUCTION

15.6 DIRECTION OF INDUCED E.M.F – LENZ'S LAW

15.7 A.C GENERATOR

1	2	3	4	5	6	7	8	9	10	11	12
A	B	D	C	D	B	A	D	A	A	C	D

13	14	15	16
D	B	B	B

15.8 MUTUAL INDUCTION

15.9 TRANSFORMER

15.10 HIGH VOLTAGE TRANSMISSION

1	2	3	4	5	6	7	8	9	10	11	12
B	A	B	C	A	A	B	B	A	B	B	A
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
B	A	C	D	A	D	C	A	B	C	D	C

25
A

TEXT BOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

i. Which statement is true about the magnetic poles? ***(K.B)***

(a) opposite poles repel (b) like poles attract
(c) magnetic poles do not effect each other. (d) a single magnetic pole does not exist

ii. What is direction of the magnetic field lines inside a bar magnet? ***(K.B)*** **(LHR 2017)**

(a) from the pole of 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 ***(K.B)*** **(LHR 2015, GRW 2016)**

(a) small mass (b) stationary positive charge
(c) stationary negative charge (d) magnetic campus

iv. If the current in a wire which is placed perpendicular to a magnetic field increases, the force on the wire ***(K.B)*** **(LHR 2014)**

(a) increase (b) decrease
(c) remain the same (d) be zero

v. A D.C motor converts: ***(K.B)***

(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.B)***

(a) the armature (b) the commutator
(c) the brushes (d) the slip rings

vii. The direction of induced e.m.f in a circuit in accordance with conservation of ***(K.B)*** **(LHR, GRW 2017)**

(a) mass (b) charge
(c) momentum (d) energy

viii. The step-up transformer: ***(K.B)***

(a) increase the input current (b) increases the input voltage
(c) has more turns in the primary (d) has less turns in the secondary

ix. The turn ratios of a transformer is 10. It means: ***(U.B)*** **(GRW 2014, 2015, 2017)**

(a) $Is = 101_P$ (b) $N_s = N_p/10$
(c) $N_s = 10N_p$ (d) $V_s = Vp/10$

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
d	b	d	a	c	b	d	b	c

REVIEW QUESTIONS

15.1 Demonstrate by an experiment that a magnetic field is produced around a straight current carrying conductor. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.1 & 15.2, Long Question-1)

15.2 State and explain the rule by which the direction of the lines of force of magnetic field around a current carrying conductor can be determined. ***(K.B)***

Ans: (See Topic 15.1 & 15.2, Short Question-2)

15.3 Your are given an unmarked magnetized steel bar and bar magnet its north and south ends marked N and S respectively. State how would you determine the polarity at each and the unmarked bar? ***(K.B)***

POLARITY OF UNMARKED BAR MAGNET

Ans: When one end of unmarked magnet bring close to end 'N' of marked magnet. If marked magnet attract the unmarked then this show that there is south pole on unmarked and if 'N' pole of marked magnet repel the end of unmarked, this show that there is also north 'N' pole of unmarked magnet.

15.4 When a straight current carrying conductor is placed in a magnetic field, it experiences a force. State the rule by which the direction of this force can be found out. ***(K.B)***

Ans: (See Topic 15.1 & 15.2, Short Question-4)

15.5 State that a current carrying coil in a magnetic field experiences a torque. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.3 & 15.4, Long Question-1)

15.6 What is an electric motor? Explain the working principle of D.C motor? ***(K.B+U.B+A.B)***

Ans: (See Topic 15.3 & 15.4, Long Question-2)

15. 7 Describe a simple experiment to demonstrate that a changing magnetic field can induce e.m.f in a circuit. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-1)

15.8 What are the factors which affect the magnitude of the e.m.f induced in a circuit by a changing magnetic field? ***(K.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Short Question-10)

15.9 Describe the direction of an induced e.m.f in a circuit? How this phenomenon is related to the conservation of energy? ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-3)

15. 10 Draw a labeled diagram to illustrate the structure and working of A.C. generator. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-4)

15.11 What do you understand by the term mutual induction? ***(K.B+U.B+A.B)***

Ans: (See Topic 15.5, 15.6 & 15.7, Long Question-1)

15.12 What is transformer Explain the working of transformer in connection with mutual induction. ***(K.B+U.B+A.B)***

Ans: (See Topic 15.8, 15.9 & 15.10, Long Question-1)

15.13 The voltage chosen for the transmission of electrical power over large distance is many time greater than the voltage of the domestic supply. State two reasons why electrical power is transmitted at high voltage *(K.B+U.B+A.B)*

Ans: (See Topic 15.8, 15.9 & 15.10, Long Question-2)

15.14 Why is the voltage used for the domestic supply much lower than the voltage at which the power is transmitted. *(K.B+U.B+A.B)*

Ans: (See Topic 15.8, 15.9 & 15.10, Short Question-7)

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 the magnet.

Ans: **IDENTIFICATION OF MAGNET**

Bring an iron strip close to each bar one by one. The iron bar which does not affect the iron strip is not a magnet.

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

Ans: **GENERATION OF CURRENT**

By moving a magnet and coil towards each other or away form each other would induce voltage in the coil. This induce voltage will cause current in the coil. You can also induce current in the coil by moving magnet and keeping the coil fixed and vice versa.

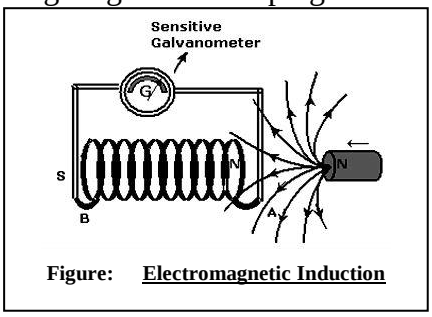


Figure: Electromagnetic Induction

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

Ans: **DEVICE**

Motor is an electrical device which can be used to convert electrical energy into mechanical energy as in fans.

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?

Ans: **DIRECTION OF SWINGING OF COIL**

The coil will swing opposite to the direction of motion of the magnet according the lenz's law. It is due to the fact that current in the coil is always induced in such a way so as to cancel the cause which induces it.

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?

Ans: **RELATIVE MOTION OF WIRE**

To generate maximum voltage through the conductor, it must be moving perpendicular to the direction of magnetic field in this case maximum magnetic force will act upon the conductor.

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

Ans: **DIFFERENTIATION**

The differences between generator and a motor are as follows.

Generator	Motor
Conversion of Energy	
• Generator converts mechanical energy into electrical energy.	• Motor converts electrical energy into mechanical energy.
Mechanism	
• Generator produces current.	• Motor drives current.
Construction	
• Generators have slip rings.	• Motors have split rings.

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

Ans: **PURPOSE OF CARBON BRUSHES**

To reverse the direction of current the connection to coil is made through an arrangement of brushes and a ring that is split into two halves, called splitting commutator. The split ring is arranged so that each half of the commutator changes the brushes just as the coil reaches the vertical position. Changing brushes reverse the current in the loop.

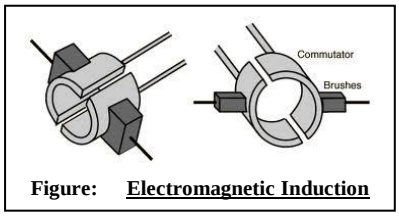
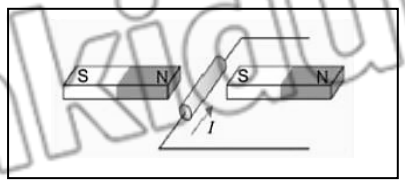


Figure: Electromagnetic Induction

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

Ans: **DIRECTION OF MOTION OF WIRE**

According to Fleming's left hand rule it will move downward direction.



15.9 Can a transformer operate on direct current?

Ans: **REASON OF A.C IN TRANSFORMER**

No, the cycle doesn't change in D,C. that is why there is not change in magnetic flux in core of transformer, that is why, there is no change of flux in secondary coil and current is not induced.

NUMERICAL PROBLEMS *(U.B+A.B)*

15.1 A transformer is needed to convert a mains 240 V supply into a 12V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil.

(LHR 2014, 2015, GRW 2015)

Solution:

Given Data:

Primary Voltage = V_p = 240 V

Secondary Voltage = V_s = 12V

Number of turns in primary = N_p = 2000

To Find:

Number of turns in secondary = N_s = ?

Calculations:

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

$$Ns = \frac{Vs \times Np}{Vp}$$

$$= \frac{12 \times 2000}{240}$$

$$Ns = 100$$

Result:

Hence, Secondary coil of transformer consist of 100 turns.

15.2 A step-up transformer has a turn ratios of 1:100.An alternating supply of 20V is connected across the primary coil. What is secondary voltage? **(LHR 2015)**

Solution:

Given Data:

Turn ratio of step-up transformer $N_p : N_s = 1:100$

Primary Voltage = $V_p = 20V$

To Find:

Secondary Voltage = V_s = ?

Formula:

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

$$\frac{N_p}{N_s} = \frac{1}{100}$$

Calculations:

$$Vs = \frac{N_s \times V_p}{N_p} = \frac{100}{1} \times 20$$

V_s = 2000 Volt

Result:

Hence, Secondary voltage obtained from transformer will be 2000 volts.

15.3 A step – down transformer has a turns ratio of 1:100. An ac voltage of amplitude 170V is applied to the primary. If the current in the primary is 1.0 mA, what is the current in the secondary?

Solution:

Given Data:

Turn ratio of step – down transformer

$= N_s : N_p = 1:100$

$= \frac{N_s}{N_p} = \frac{1}{100}$

Primary Voltage $= V_p = 170v$

Primary current $= I_p = ImA = 1 \times 10^{-3}$ A

To Find:

Secondary current $= I_s = ?$

Formula:

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

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

Calculations:

$$V_s = \frac{1}{100} \times 170 = 1.7V$$

For an ideal transformer

Power of primary =Power of secondary

$P_p = P_s$

$I_p V_p = I_s V_s$

$$\frac{I_p V_p}{V_s} = I_s$$

$$\frac{1 \times 10^{-3} \times 170}{1.7} = I_s$$

0.1 A = I_s $\Rightarrow$ I_s = 0.1A Ans

Result:

Hence, Current of 0.1 A will be obtained from secondary coil.

15.4 A transformer, designed to convert the voltage from 240 V a.c. mains to 12V, has 4000 turns on the primary coil. How may turns should be on the secondary coil? If the transformer were 100% efficient, what current would flow through the primary coil when the current in the secondary coil was 0.4A?

Solution:

Given Data:

Primary Voltage $= V_p = 240V$

Secondary Voltage $= V_s = 12V$

Number of turns in Primary $= N_p = 4000$

To Find:

Number of turns in secondary $= N_s = ?$

Formula:

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

Calculations:

$$Ns = \frac{V_s \times N_p}{v_p} = \frac{12 \times 4000}{240}$$

$N_s = 200$ Ans

$I_p = ?$

$I_s = 0.4A$

$P_p = P_s$

$I_p V_p = I_s V_s$

$$Ip = \frac{I_s V_s}{V_p} = \frac{0.4 \times 12}{240}$$

I_p = 0.02 A

Result:

Hence, Current of 0.2 A will be given to primary coil.

15.5 A power station generates 500 MW of electrical power which is fed to a transmission line. What current would flow in the transmission line if the input voltage is 250 kV?

Solution:

Given Data:

Voltage =V = 250 x 10^3V

Power = P = 500 x 10^6W

To Find:

Current flowing transmission =I = ?

Formula:

P = IV

Calculations:

$$\frac{P}{V} = I$$

$$\frac{500\times10^6}{250\times10^3} = 1$$

$$2\times10^3 A = 1 \qquad \Rightarrow \quad I = 2KA$$

Ans

Result:

Hence, Current of 2kA will be flown through transmission lines.

SELF TEST

Time: 40 min. **Marks: 25**

Q.1 Four possible answers (A), (B), (C) & (D) to each question are given, mark the correct answer. (6×1=6)

1. The presence of a magnetic field can be detected by a:

(A) Small mass (B) Stationary positive charge

(C) Stationary negative charge (D) Magnetic campus

2. A step down transformer:

(A) Decreases input current (B) Decreases input voltage

(C) Has more turns in secondary coil (D) Has less turns in primary coil

3. According to Faraday's law, the induced emf and change in flux are:

(A) Directly proportional (B) Inversely proportional

(C) Equal (D) Opposite

4. A device which is used to convert electrical energy into rotational kinetic energy:

(A) Transformer (B) A.C Generator

(C) D.C Motor (D) All of them

5. Weak ionic current that travel along the nerve can produce the:

(A) Electric effect (B) Magnetic effect

(C) Electric and Magnetic field (D) All of these

6. Shape of Magnetic lines of force in straight conductor are:

(A) Straight (B) Elliptical

(C) Circular (D) All of them

Q.2 Give short answers to following questions. (5×2=10)

i. Define electromagnetism.

ii. Differentiate between primary and secondary coil.

iii. Which factors increase the force on armature?

iv. State Fleming's left hand rule.

v. State Faraday's law of electromagnetic induction.

Q.3 Answer the following questions in detail. (4+5=9)

a) What is an electric motor? Write its construction and working.

b) A transformer is needed to convert a mains 240 V supply into a 12V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil.

Note:

Parents or guardians can conduct this test in their supervision in order to check the skill of students.