FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

CHAPTER 1 SOLUTION

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PARUL UNIVERSITY

DIPLOMA STUDIES

ELECTRICAL ENGINEERING DEPATEMENT

CHAPTER – 1 OVERVIEW OF ELECTRIC COMPONENTS AND SIGNALS

2 MARKS QUESTIONS

1. Give application of Diode.

- The most basic function would be changing AC current to DC current by removing some part of the signal. This functionality would make them rectifiers. They are used in electrical switches and are used in surge protectors because they can prevent a spike in the voltage.
- Diodes help in performing digital logic. Millions of diodes are used similar to logic gates and used in modern processors.
- They are used for isolating signals from a supply. For example, one of the major uses of diodes is to remove negative signals from AC current. This is known as signal demodulation. This function is basically used in radios as a filtering system in order to extract radio signals from a carrier wave.
- The light emitting diodes or LEDs are used in sensors and also in laser devices any many other light illumination devices.
- Diodes are the basis of op-amps and transistors.

2. Give application of Transistor.

- The core use of transistors includes switching applications or both amplification and switching.
- There is a kind of transistors that produce current flow depending on the amount of light shined upon them; those are known as phototransistors.
- Bipolar Junction Transistors (BJT) can cause a greater current flow from the emitter to the collector when a small amount of current is passed through the base.
- Schottky Transistors divert high input currents and prevent the transistors from saturating.

- Multiple Emitter Transistors are used in Transistor-Transistor Logic (TTL) and NAND logic gates.
- Dual Gate MOSFETs are used in RF mixers/multipliers and RF amplifiers where two controlled gates are required in a series.
- Avalanche Transistors can switch high currents in less than nanosecond transition times.

3. What are active Components?

Active Components: An active component is an electronic component which supplies energy to a circuit or ability to control electron flow (i.e., the flow of charge). All electronic circuits must contain at least one active component.

4. Write Examples of active components.

Active component has two types:

- Energy source: Voltage source and current source.
- Signal processing component which can process the electrical signal.
- All different types of transistors (BJT, FET, MOSFET, JFET)
- Diodes (Zener diode, photo diode, LED etc.)

5. What are passive Components?

Passive Components: Electrical and electronic circuits consist of connecting together many different components to form a complete and closed circuit. The three main passive components used in any circuit are the: Resistor, the Capacitor and the Inductor. All three of these passive components have one thing in common, they limit the flow of electrical current through a circuit but in very different ways.

- Passive components consume electrical energy and therefore cannot increase or amplify the power of any electrical signals applied to them, simply because they are passive and as such will always have a gain of less than one.

6. Write Examples of passive components.

- The three basic passive electronic components are resistors, capacitors, and inductors. Other passive components include transformers, diodes, thermistors, varactors, transducers, and many other common components.

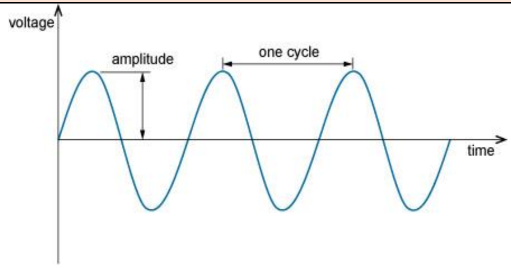
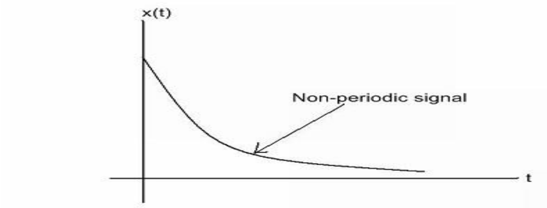
7. Define SCR and give applications of it.

- **Silicon Controlled Rectifiers or SCRs** for short is a type of power electronics switch. It has three terminals called Anode, Cathode, and Gate. By default, the switch is open and no current flows between the Anode and Cathode terminals of the SCR. When a small current is applied to the gate pin, the switch is closed and a large amount of current can be allowed to pass between the Anode and Cathode terminals.
- SCRs are mainly used in devices where the control of high power possibly coupled with high voltage, is demanded. Their operation makes them suitable for use in medium – to – high voltage AC Power control applications, such as lamp dimming, power regulators and motor control.

3 MARKS QUESTIONS

1. Give compression between periodical and non-periodical signals.

Periodic Signal	Aperiodic / Non periodic signal
A signal which repeats itself after a specific interval of time is called periodic signal.	A signal which does not repeat itself after a specific interval of time is called Aperiodic or Non periodic signal.
A signal that repeats its pattern over a period is called periodic signal.	A signal that does not repeat its pattern over a period is called Aperiodic or Non periodic signal.
They can be represented by a mathematical equation.	They cannot be represented by any mathematical equation.
Their value can be determined at any point of time.	Their value cannot be determined with certainty at any given point of time.
They are deterministic signals.	They are random signals.
Example: Sine wave, cosine, sawtooth	Example: Sound signals from radio, all

<table>
<tr><td>and square etc.</td><td>types of noise signals.</td></tr>
<tr><td>
</td><td>
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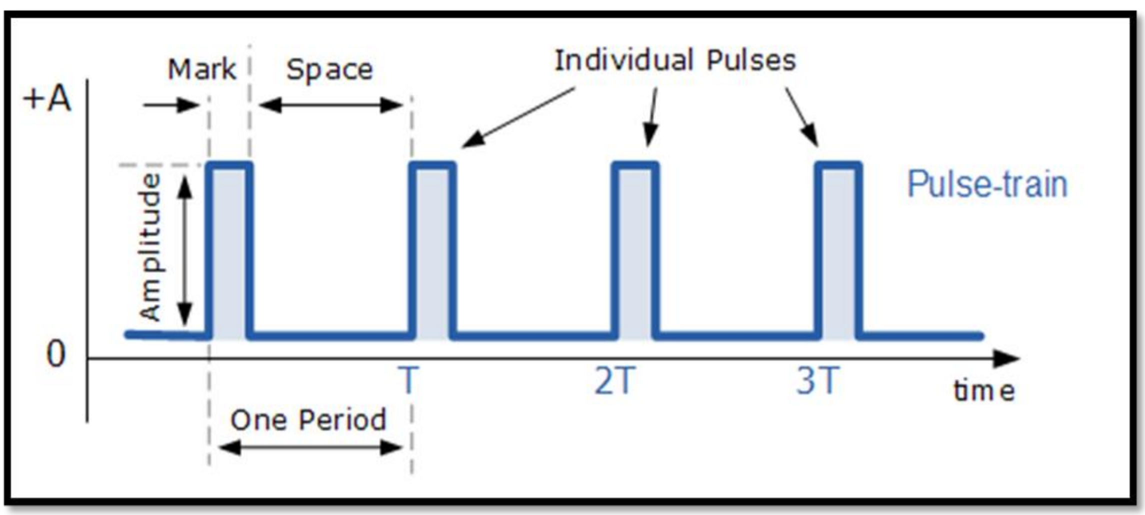
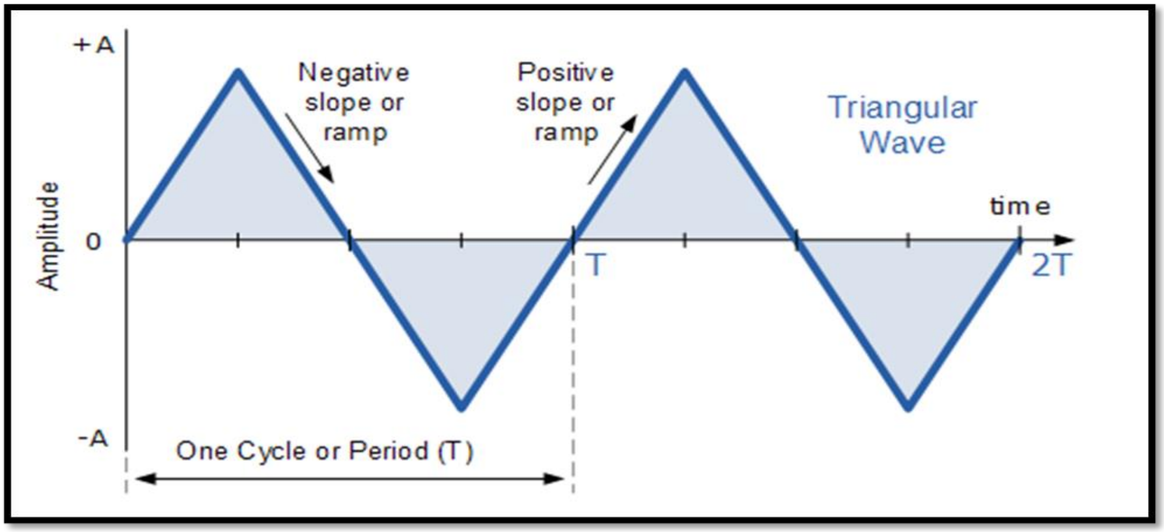
2. Explain pulse Signal and Triangular Signal.

- A Pulse Waveform or "Pulse-train" as they are more commonly called, is a type of non-sinusoidal waveform that is similar to the rectangular waveform we looked at earlier. The difference being that the exact shape of the pulse is determined by the "Mark-to-Space" ratio of the period and for a pulse or trigger waveform the Mark portion of the wave is very short with a rapid rise and decay shape as shown below.

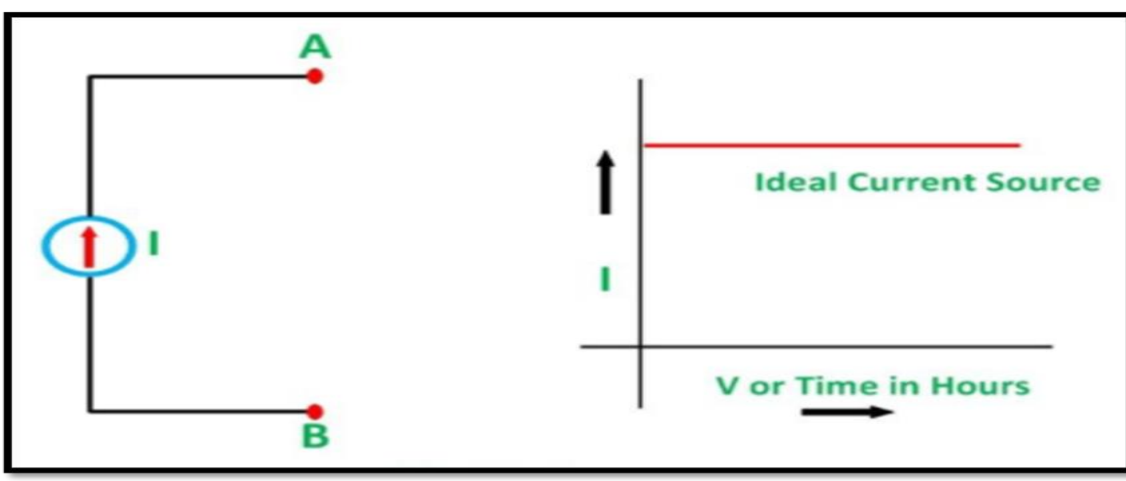


- Triangular Waveforms are generally bi-directional non-sinusoidal waveforms that oscillate between a positive and a negative peak value. Although called a triangular waveform, the triangular wave is actually more of a symmetrical linear ramp waveform because it is simply a slow rising and falling voltage signal at a constant frequency or rate. The rate at which the voltage changes between each ramp direction is equal during both halves of the cycle as shown below.

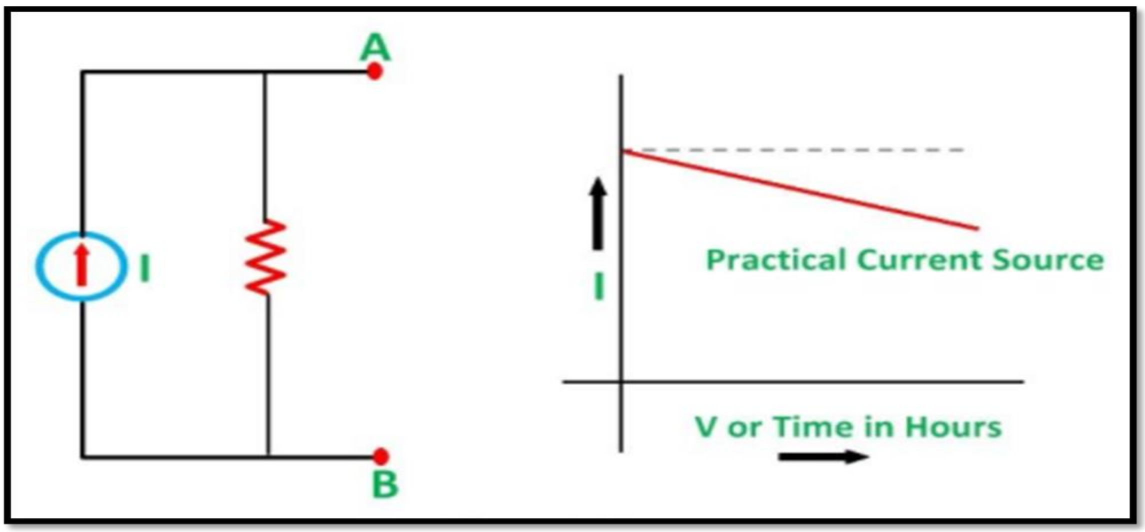


3. Draw and explain ideal and practical current source.

- **An ideal current source** is a two terminal device which supplies constant current irrespective of load resistance. The value of current will be constant with respect to time and load resistance. This means that the power delivering capability is infinite for this source.
- An ideal current source has infinite parallel resistance connected to it. Therefore, the output current is independent of voltage of the source terminals. No such current source exists in the world, this is just a concept. However, every current source is designed to approach closer to the ideal one.
- The internal resistance of current source is the value of resistance connected across its terminal. This internal resistance of ideal current source is infinite.

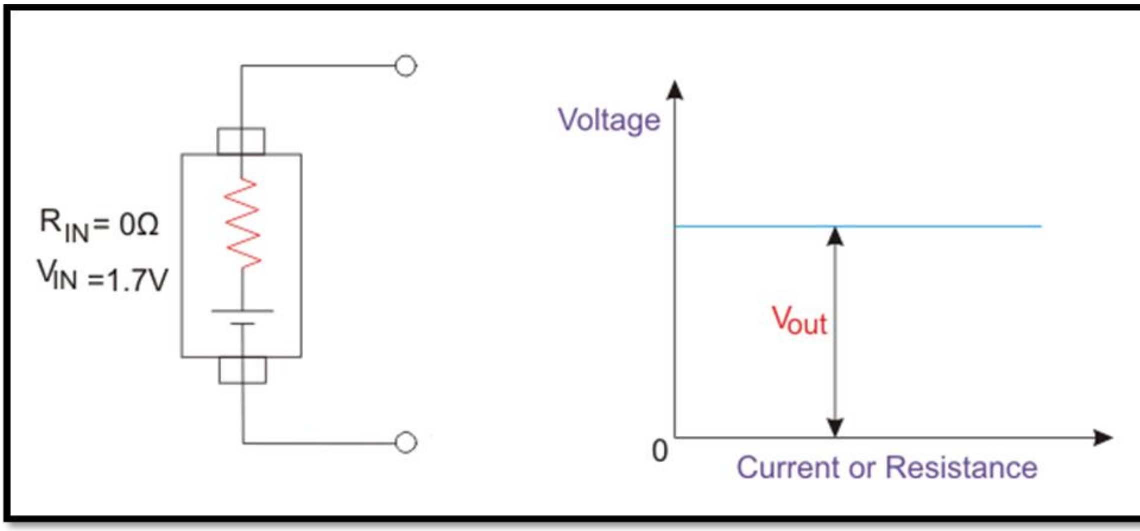


- **Practical current source** has resistance or impedance and it is connected to it. The current supplied by the current source decreases when the value of resistance or impedance increases.
- To better understand, let us consider a practical current source as shown below.

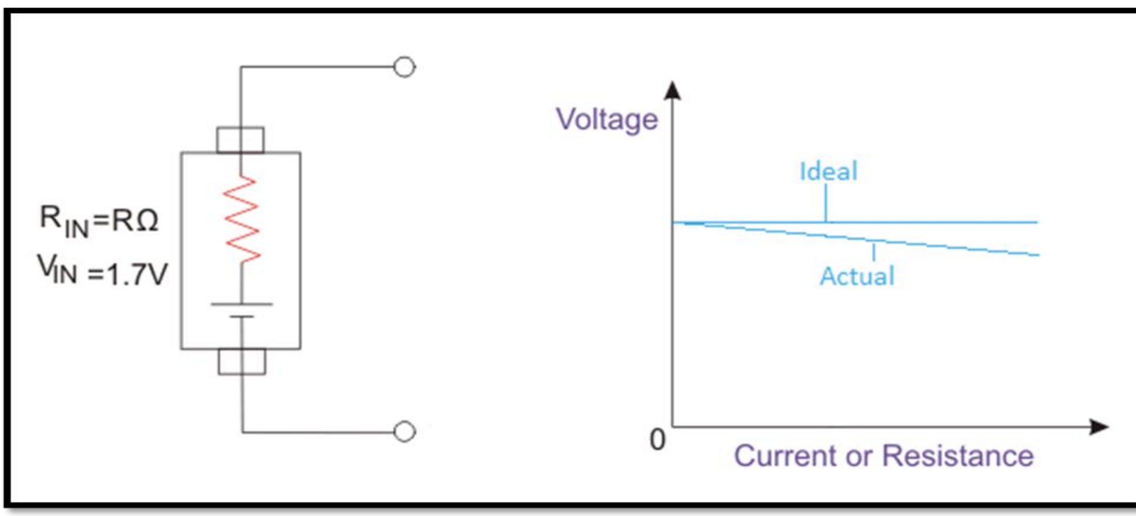


4. Draw and explain ideal and practical voltage source.

- **An ideal voltage source** is capable to maintain the constant voltage across its terminals. The voltage across the voltage source terminals remains constant and the voltage is independent of the current.
- The voltage across the terminals of an ideal voltage source remains constant and the voltage does not drop with increase in the circuit current. The voltage across an ideal voltage source with change in the circuit current.
- The voltage of an ideal voltage source remains constant if there does not happen voltage drop across the internal resistance of the voltage source. The voltage source has certain resistance which cause voltage drop across the internal resistance. An ideal voltage source must have zero internal resistance. In this condition, the voltage across the load will be equal to the voltage across the terminals of the voltage source.
- The ideal voltage source is shown in figure below.



- **practical voltage source** having an internal resistance of RΩ. Due to the internal resistance, there will be small amount of voltage drop in the R. So, the output voltage will be reduced to some volt from 1.7V.

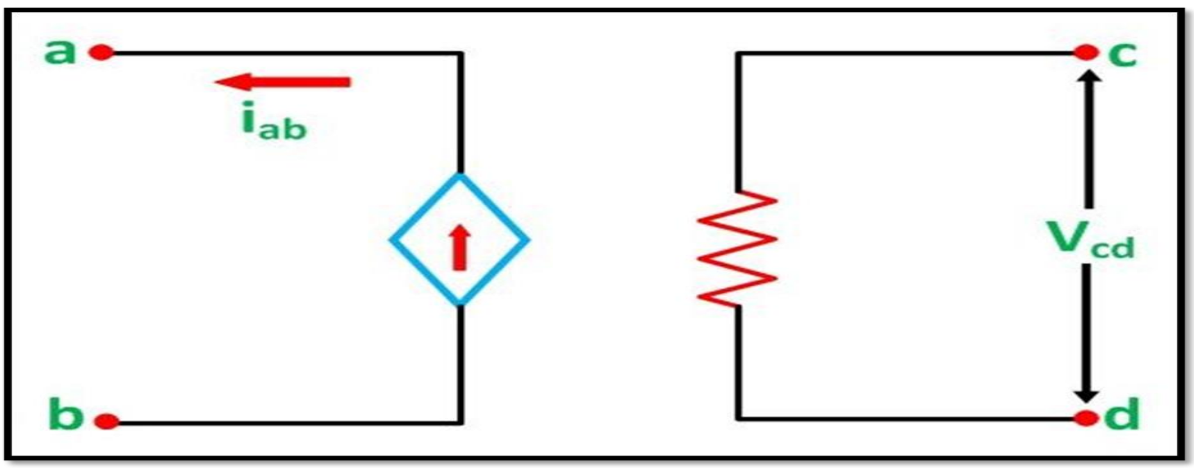


4-MARKS QUESTIONS

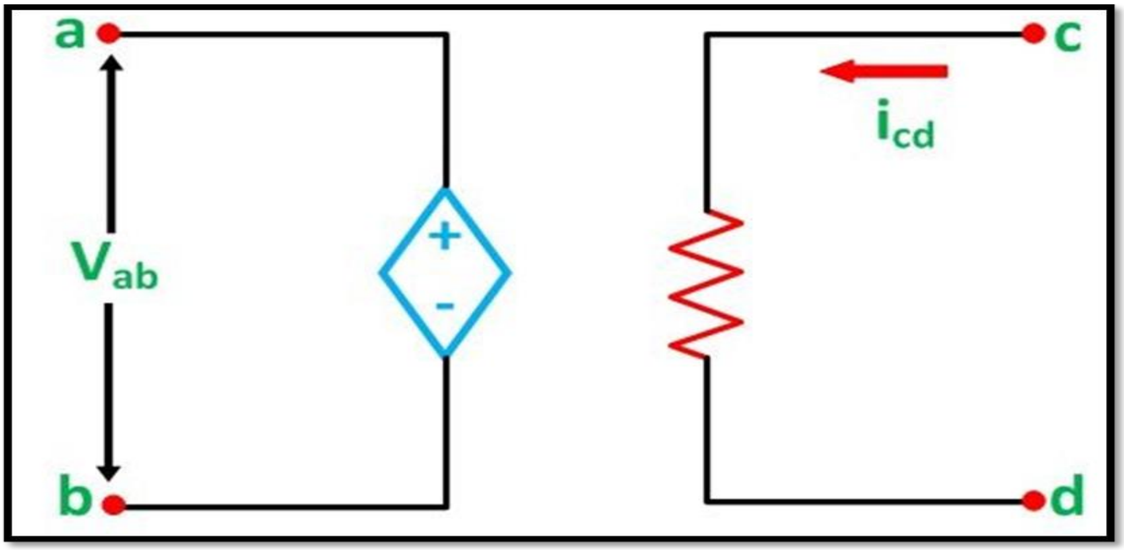
1. Explain Voltage controlled current source (VCCS) and Current controlled voltage source (CCVS).

- **Voltage controlled current source (VCCS):** Voltage Controlled Current Source is that where the current is dependent or controlled by the changing of voltage elsewhere in the circuit. In short, it is known as VCCS. For dependent sources, sometimes voltage is controlled by current, and sometimes current is controlled by voltage. According to those, there are four types of dependent sources. Anyway, the basic concept of the VCCS is, that voltage controls the output current. So, the output current Iout is proportional to the controlled input voltage Vin.

- The voltage-controlled current output is determined by the equation, IOUT = αVIN
- Here, IOUT = Output Current
- VIN = Input Voltage
- α(alpha) = Multiplying Constant, sometimes it is known as transconductance of the current source.



- **Current controlled voltage source (CCVS):** The current-controlled voltage source is that where the terminal voltage is dependent or controlled by the current flow elsewhere in the circuit. In short, it is known as CCVS. It is also a type of dependent source. In the previous article, we have learned about voltage control voltage source where the terminal is voltage dependent upon the voltage elsewhere in the circuit but here the concept is different. Here, changes in current flow elsewhere in the circuit can change the terminal voltage.
- Here, the current-controlled output voltage is determined by VOUT = ρIIN
- Here, VOUT = Output Dependent Voltage
- IIN = Input Current
- ρ(rho) = Multiplying constant or efficient of the voltage source. It is sometimes known as trans resistance.



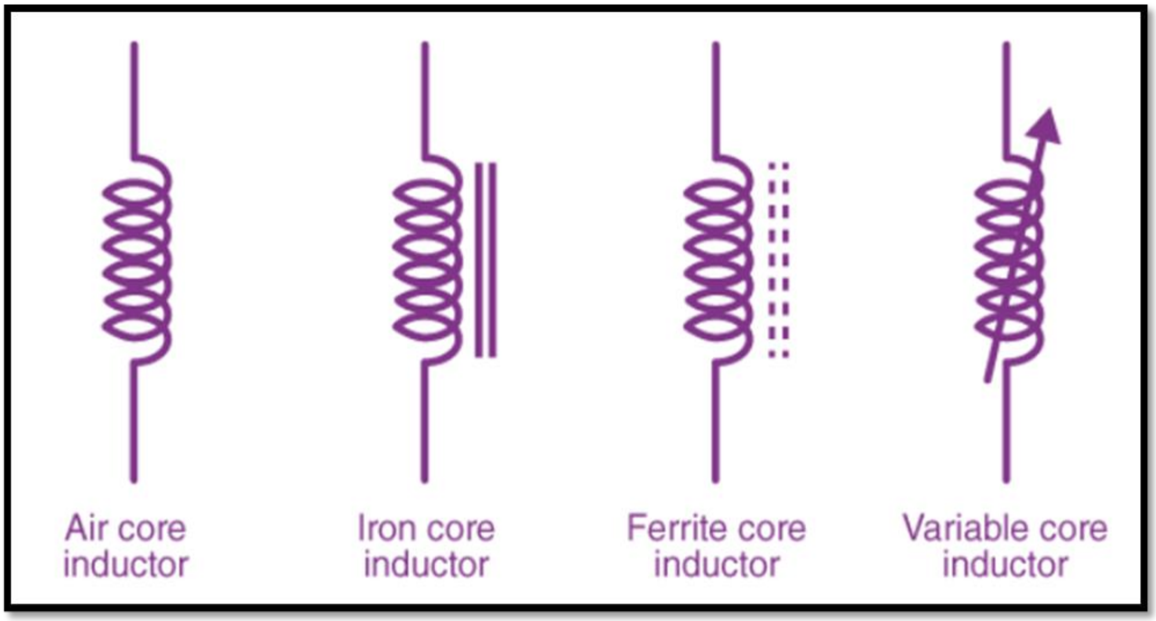
2. Explain any two Passive components.

- **Resistance:** The property of material which oppose the flow of electrons is known as resistance of the circuit.
- It is denoted by letter R.
- Its unit is ohm (Ω).
- R= V/I
- **Resistance id depends upon below mentioned factors.**
  Length of material.
  Cross sectional area.
  Temperature.
  Type of Material.

- **Inductor:** Inductors much like conductors and resistors are simple components that are used in electronic devices to carry out specific functions. Normally, inductors are coil-like structures that are found in electronic circuits. The coil is an insulated wire that is looped around the central core.
- Inductors are mostly used to decrease or control the electric spikes by storing energy temporarily in an electromagnetic field and then releasing it back into the circuit.
- An inductor is a passive component that is used in most power electronic circuits to store energy in the form of magnetic energy when electricity is

applied to it. One of the key properties of an inductor is that it impedes or opposes any change in the amount of current flowing through it. Whenever the current across the inductor changes it either acquires charge or loses the charge in order to equalize the current passing through it. The inductor is also called a choke, reactor or just coil.

- The S.I. unit of inductance is henry (H) and when we measure magnetic circuits it is equivalent to weber/ampere. It is denoted by the symbol L.



FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

CAPTER-2 SOLUTION

PARUL UNIVERSITY

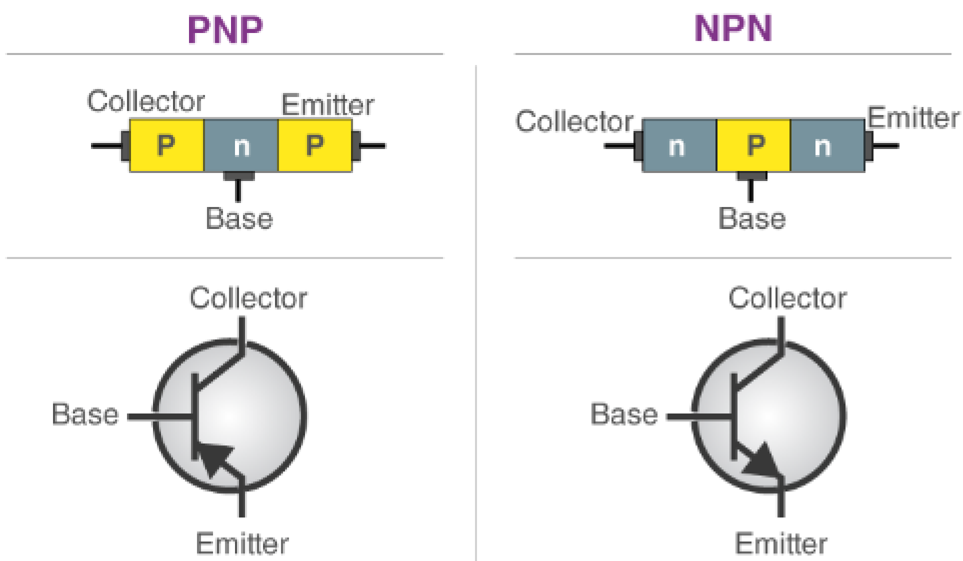
DIPLOMA STUDIES

ELECTRICAL ENGINEERING DEPATEMENT

CHAPTER-2 INTRODUCTION TO SEMICONDUCTOR COMPONENTS

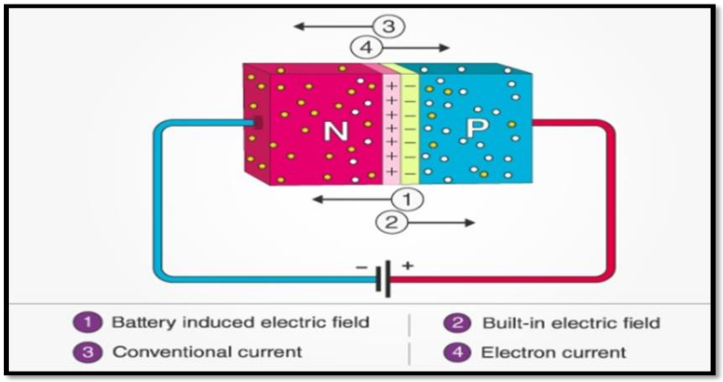
2 MARKS QUESTIONS

1. Draw the symbol of NPN and PNP transistor.



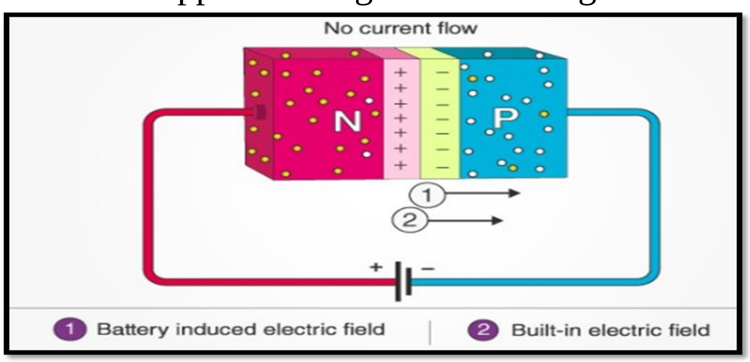
2. Define forward bias with diagram.

- When the p-type is connected to the battery's positive terminal and the n-type to the negative terminal, then the P-N junction is said to be forward-biased. When the P-N junction is forward biased, the built-in electric field at the P-N junction and the applied electric field are in opposite directions.
- When both the electric fields add up, the resultant electric field has a magnitude lesser than the built-in electric field.
- This results in a less resistive and thinner depletion region. The depletion region's resistance becomes negligible when the applied voltage is large. In silicon, at the voltage of 0.6 V, the resistance of the depletion region becomes completely negligible, and the current flows across it unimpeded.



3. Define reverse bias with diagram.

- When the p-type is connected to the battery's negative terminal and the n-type is connected to the positive side, the P-N junction is reverse biased. In this case, the built-in electric field and the applied electric field are in the same direction.
- When the two fields are added, the resultant electric field is in the same direction as the built-in electric field, creating a more resistive, thicker depletion region. The depletion region becomes more resistive and thicker if the applied voltage becomes larger.



4. What is knee voltage? Give its value for Ge and Si.

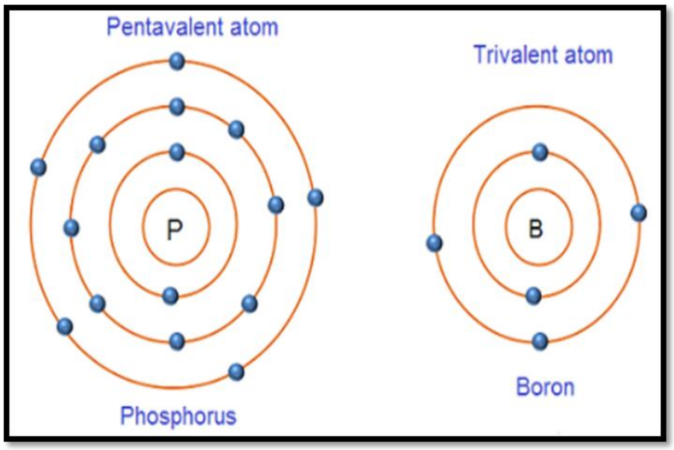
- The voltage is cross toward the barrier potential, the diode current raises quickly and diode performs greatly. This barrier voltage at which the flow of current will increase is known as knee voltage.
- The knee voltage for a silicon diode is approximately 0.7 volt and for a germanium diode 0.3 volt.

5. Give example of Trivalent Impurities.

- Trivalent impurity atoms have 3 valence electrons. The various examples of trivalent impurities include Boron (B), Gallium (G), Indium(In), Aluminum(Al).
- Boron is a substance consisting of atoms which all have the same number of protons. The atomic number of boron is 5 i.e. 5 protons. Boron atom has 5 electrons (2 electrons in first orbit and 3 electrons in the outermost orbit).

6. Give example of Pentavalent Impurities.

- Pentavalent impurity atoms have 5 valence electrons. The various examples of pentavalent impurity atoms include Phosphorus (P), Arsenic (As), Antimony (Sb), etc. The atomic structure of pentavalent atom (phosphorus) and trivalent atom (boron) is shown in below fig.



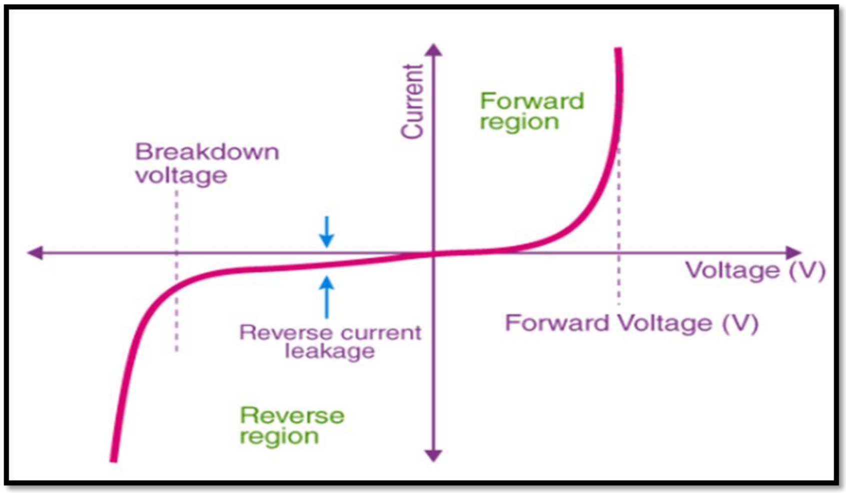
- Phosphorus is a substance consisting of atoms which all have the same number of protons. The atomic number of phosphorus is 15 i.e. 15 protons. The number of protons in the nucleus of an atom is called atomic number.
- Phosphorus atom has 15 electrons (2 electrons in first orbit, 8 electrons in second orbit and 5 electrons in the outermost orbit).

3 MARKS QUESTIONS

1. Explain V-I characteristics of PN junction diode.

- VI characteristics of P-N junction diodes is a curve between the voltage and current through the circuit. Voltage is taken along the x-axis while the current is taken along the y-axis. The above graph is the V-I characteristics curve of the P-N junction diode. With the help of the curve, we can understand that there are three regions in which the diode works, and they are:

- **Zero bias**
- **Forward bias**
- **Reverse bias**

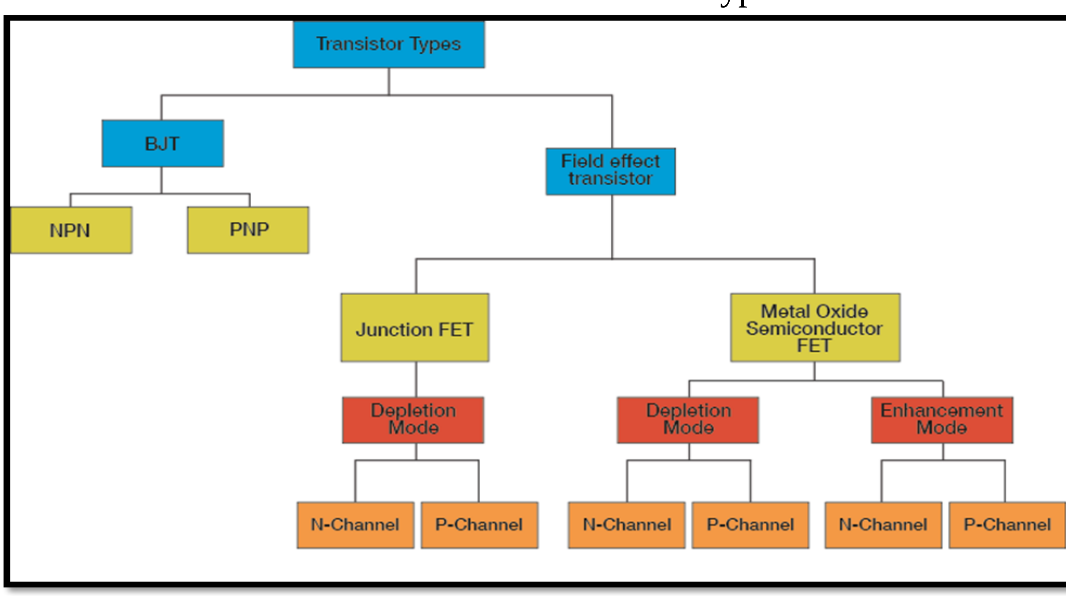


- When the P-N junction diode is in zero bias condition, there is no external voltage applied and this means that the potential barrier at the junction does not allow the flow of current.
- When the P-N junction diode is in forward bias condition, the p-type is connected to the positive terminal while the n-type is connected to the negative terminal of the external voltage. When the diode is arranged in this manner, there is a reduction in the potential barrier. For silicone diodes, when the voltage is 0.7 V and for germanium diodes, when the voltage is 0.3 V, the potential barriers decrease, and there is a flow of current.
- When the diode is in forward bias, the current increases slowly, and the curve obtained is non-linear as the voltage applied to the diode overcomes the potential barrier. Once the diode overcomes the potential barrier, the diode behaves normally, and the curve rises sharply as the external voltage increases, and the curve obtained is linear.
- When the P-N junction diode is in negative bias condition, the p-type is connected to the negative terminal while the n-type is connected to the positive terminal of the external voltage. This results in an increase in the potential barrier. Reverse saturation current flows in the beginning as minority carriers are present in the junction.

- When the applied voltage is increased, the minority charges will have increased kinetic energy which affects the majority charges. This is the stage when the diode breaks down. This may also destroy the diode.

2. State and explain classification of transistor.

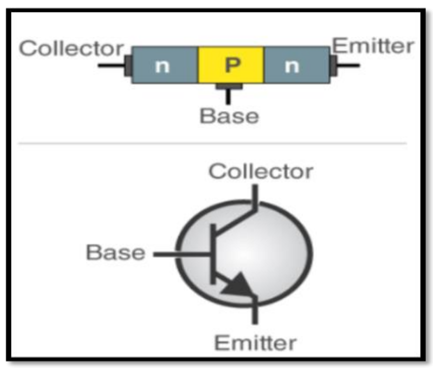
- Transistor is a semiconductor device which is used to either amplify the signals or to act as an electrically controlled switch. A Transistor is a three terminal device and a small current / voltage at one terminal (or lead) will control a large flow of current between the other two terminals (leads).
- Since a long time, the vacuum tubes are replaced with transistors because the transistors have more benefits over vacuum tubes. Transistors are small in size and it requires low energy for operation and also it has low power dissipation. The Transistor is one of the important active components (a device which can produce an output signal higher power than that in the input signal).
- Transistor is an essential component is almost every electronic circuit like: Amplifiers, Switching, Oscillators, Voltage Regulators, Power Supplies and most importantly, the Digital Logic ICs.
- From the time of invention of the first transistor to the present day, transistors are classified into different types depending either on their construction or their operation. The following tree diagram explains a Basic Classification of different Transistor types.



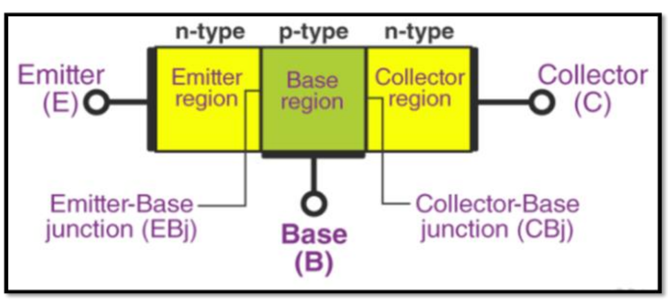
- The classification of transistors can be easily understood by observing the above tree diagram. Transistors are basically classified into two types. They are: Bipolar Junction Transistors (BJT) and Field Effect Transistors (FET). The BJTs are again classified into NPN and PNP transistors. The FET transistors are classified into JFET and MOSFET.
- Junction FET transistors are further classified into N–Channel JFET and P–Channel JFET depending on their construction. MOSFETs are classified into Depletion Mode and Enhancement Mode. Again, depletion and enhancement mode transistors are further classified into respective N–Channel and P–Channel.

3. Explain the construction of NPN transistor.

- The NPN transistor consists of two n-type semiconductors that sandwich a p-type semiconductor. Here, electrons are the majority charge carriers, while holes are the minority charge carriers. The NPN transistor is represented, as shown below.

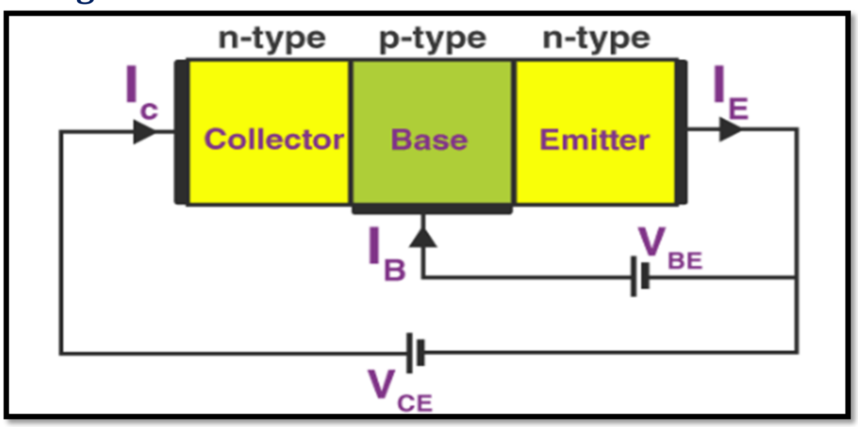


- In the above figure, we can see an arrow pointing outwards from the emitter terminal. This indicates the direction of the flow of current through the device.
- **Construction of NPN Transistor**



- The NPN transistor is made of semiconductor materials like silicon or germanium. When a p-type semiconductor material is fused between two n-type semiconductor materials, an NPN transistor is formed.
- The NPN transistor features three terminals: emitter, base and collector.
- This transistor features two diodes that are connected back to back. The diode seen between the emitter-base terminal is referred to as the emitter-base diode. The diode between collector and base terminal is known as collector-base diodes. The emitter is moderately doped, the base is lightly doped, and the collector is comparatively more doped.

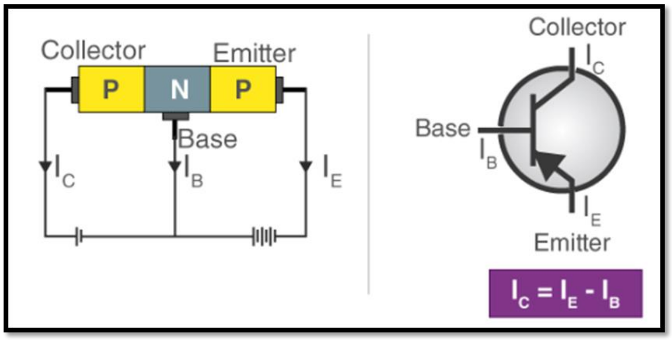
- **Working NPN Transistor**



- When the emitter-base junction is forward biased, a small voltage VBE is seen. Reverse bias voltage VCE. Due to the forward bias, the majority charge carriers in the emitter are repelled towards the base. The electron-hole recombination is very small in the base region since the base is lightly doped. Most of the electrons cross into the collector region.
- When the emitter is forward biased, electrons move towards the base and create the emitter current IE. Here, the majority charge carriers in the P-type material combine with the holes.
- Since the base of the NPN transistor is lightly doped, it lets only a few electrons to combine and the remaining current is known as the base current IB. When the collector region is reverse biased, it applies a greater force on the electrons reaching the collector junction and hence attracts the electrons at the collector.

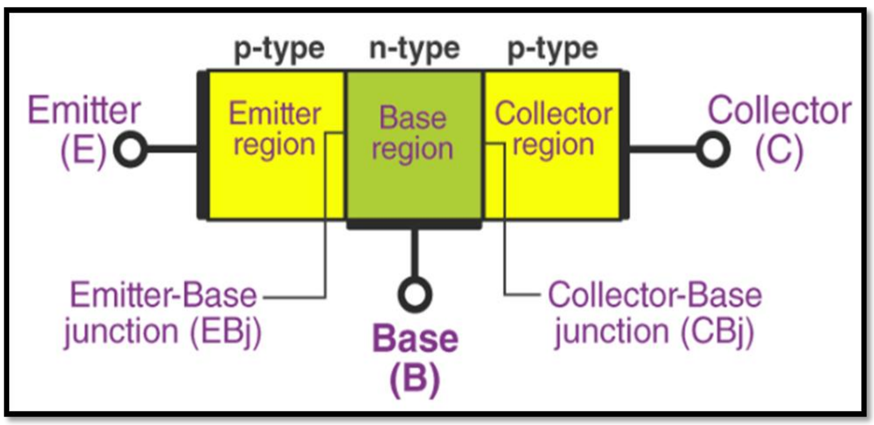
4. Explain the construction of PNP transistor.

- PNP transistors representation is as shown in the figure below.



- This bipolar PNP junction transistor is formed with three layers of semiconductor material, with two P-type regions and one N-type region. It includes three terminals:
- Emitter
- Collector
- Base
- **Emitter –** emitter part in a transistor lets it supply majority charge carriers. The emitter is always forward biased with respect to the base. Hence the majority of charge carriers are supplied to the base. The emitter of a transistor is heavily doped and moderate in size.
- **Collector –** the majority of the charge carrier supplied by the emitter is collected by the collector. The collector-base junction is always reverse biased. The collector area is moderately doped and has the capacity to collect the charge carrier supplied by the emitter.
- **Base –** The center section of the transistor is known as the base. The base forms two circuits, the input circuit with the emitter and the output circuit with the collector. The emitter-base is forward biased and offers low resistance to the circuit. The collector-base junction is in reverse bias and offers higher resistance to the circuit. The base of a transistor is lightly doped and very thin, due to which it offers the majority charge carrier to the base.
- **Construction of PNP Transistor**
- P-type semiconductors, which represent the emitter and collector, are doped heavily than N-type semiconductors, which represent the base. Hence, the depletion region at both junctions penetrates towards the N-type layer.

- In PNP transistors, in this type of transistor, majority charge carriers are holes, and minority charge carriers are electrons. The emitter emits holes and is collected at the collector.
- In a PNP transistor, the base current which enters into the collector is amplified. The flow of current is typically controlled by the base. Current flows in the opposite direction in the base. In a PNP transistor, the emitter emits “holes”, and these holes are collected by the collector.
- The base region features a large number of free electrons. But, the width of the middle layer is very small and is lightly doped. So significantly less free electrons are present in the base region.
- **Construction of NPN Transistor**



- **Working of NPN Transistor**
- Emitter current is created when the emitter-base junction is forward biased, the emitter pushes the holes towards the base region. When electrons move into the N-type semiconductor or base, they combine with the holes. The base is lightly doped and is comparatively thin.
- Hence only a few holes are combined with the electrons and the remaining are moved towards the collector space charge layer. This phenomenon generates the base current. The current is carried by holes in p-n-p transistors.

FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

CHAPTER 4 SOLUTION

PARUL UNIVERSITY

DIPLOMA STUDIES

ELECTRICAL ENGINEERING DEPATEMENT

CHAPTER – 4 ELECTRIC CIRCUIT

2 MARKS QUESTIONS

1. Define the terms 1) electric current 2) Potential difference.

Electric current: If there are less than 4 electrons in the outer orbit of the atomic structure they are known as free electrons, this free electron is having tendency to move from one atom to another atom when they experience any external force. Free electrons are electrically charged. This movement of free electrons are termed as electric current.

It is represented by the letter I, and unit is ampere.

Potential Difference: Work required to be done (or energy needed) to move unite positive charge from one point to another in the circuit is called voltage or the potential difference.

Voltage = work or energy/charge. Voltage = W/Q

2. State law of energy conversion.

Energy conversion, also termed as energy transformation, is the process of changing one form of energy into another. Energy conversion occurs everywhere and every minute of the day. There are numerous forms of energy like thermal energy, electrical energy, nuclear energy, electromagnetic energy, mechanical energy, chemical energy, sound energy, etc. On the other hand, the term Energy Transformation is used when energy changes forms from one form to another. Whether the energy is transferred or transformed, the total amount of energy doesn't change and this is known as the Law of Conservation of Energy.

The first law of thermodynamics states that

"Energy can neither be created nor destroyed, it can only be transformed from one form to another".

3. Define the terms 1) Inductor 2) Capacitor.

Inductor: Inductors much like conductors and resistors are simple components that are used in electronic devices to carry out specific functions. Normally, inductors are coil-like structures that are found in electronic circuits. The coil is an insulated wire that is looped around the central core.
Inductors are mostly used to decrease or control the electric spikes by storing energy temporarily in an electromagnetic field and then releasing it back into the circuit.

The S.I. unit of inductance is henry (H) and when we measure magnetic circuits it is equivalent to weber/ampere. It is denoted by the symbol L.

Capacitor: A capacitor is a little like a battery but they work in completely different ways. A battery is an electronic device that converts chemical energy into electrical energy whereas a capacitor is an electronic component that stores electrostatic energy in an electric field.
capacitor is a two-terminal electrical device that possesses the ability to store energy in the form of an electric charge. It consists of two electrical conductors that are separated by a distance. The space between the conductors may be filled by vacuum or with an insulating material known as a dielectric. The ability of the capacitor to store charges is known as capacitance.

4. Define the terms 1) E.M.F 2) Resistance.

E.M.F: Flow of electric charge is essential to make current to flow through a conductor. So, it is necessary to do work. And to do work, energy is required. This energy is supplied by battery. This is called electro motive force.
The force required to move the electrons from one point to another point is called electro motive force. **Its unit is volt and represented by a letter E.**

Resistance: The property of a material to oppose the flow of electric current through it is called resistance. When a conductor is given emf, electric current flows due to the flow of free electrons. When these electrons move, they collide with the atoms. So, flow of electric current is opposed. Due to this Collison, some kinetic energy is converted in to heat energy. Crystalline structures of different materials are different. So, all materials do not oppose the flow of electric current equally. That means resistance of different material is different.

It is denoted by letter R. Its unit is ohm (Ω).

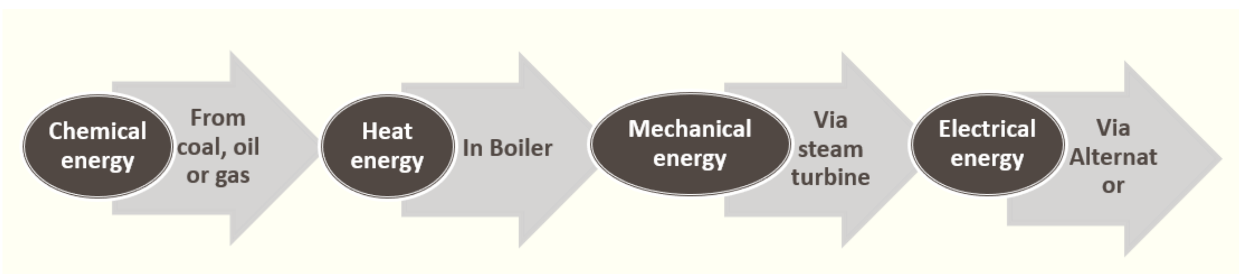
R= V/I

3 MARKS QUESTIONS

1. Draw and explain flow chart of energy transformation in thermal power and nuclear plant.

Thermal power plant

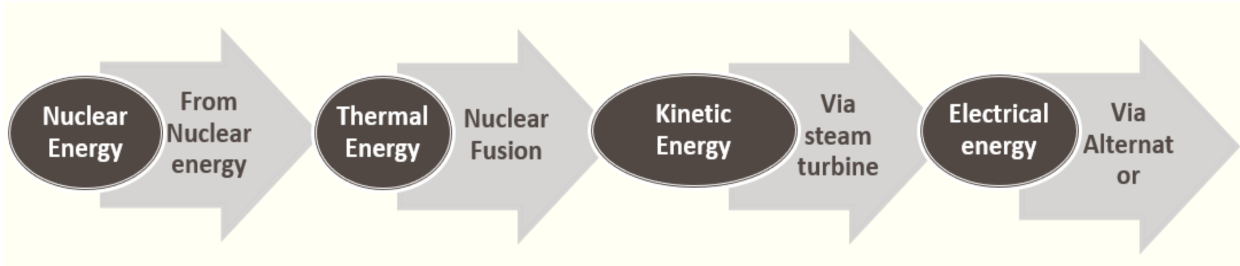
Water is heated in a boiler. Using the thermal energy released due to burning of coal, steam of very high temperature and pressure is generated. The energy in the steam drives the turbine. Thus, the generator connected to the turbine rotates and electrical energy is produced.



Energy conservation in thermal power plant

Nuclear power plant

Nuclear power plants consist of nuclear reactors. These reactors use uranium rods as fuel and heat is generated by the process of nuclear fission. Neutrons smash into the nucleus of the uranium atoms, which roughly split into half and release energy in the form of heat. Carbon dioxide gas is pumped through the reactor to take the heat away. The hot gas then heats water to form steam. This steam drives the turbines of generators to produce electricity. Thus, the steps of energy conversion are:



Energy conservation in nuclear power plant

2. Give comparisons between A.C and D.C forms of electricity.

Alternating Current	Direct Current
AC is safe to transfer longer distance even between two cities, and maintain the electric power.	DC cannot travel for a very long distance. It loses electric power.
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is dependent upon the country. But generally, the frequency is 50 Hz or 60 Hz.	DC has no frequency of zero frequency.
In AC the flow of current changes its direction backwards periodically.	It flows in a single direction steadily.
Electrons in AC keep changing its directions – backward and forward	Electrons only move in one direction – that is forward.

3. Give difference between E.M.F and Potential Difference.

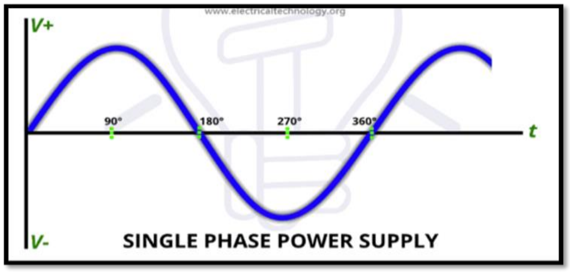
Flow of electric charge is essential to make current to flow through a conductor. So, it is necessary to do work. And to do work, energy is required. This energy is supplied by battery. This is called electro motive force.

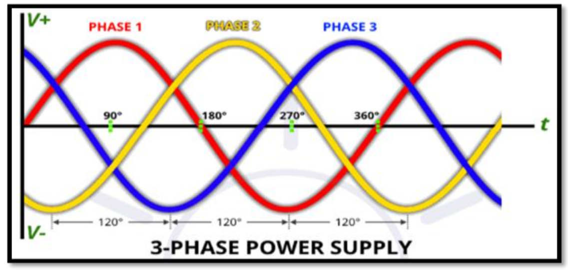
Work required to be done (or energy needed) to move unite positive charge from one point to another in the circuit is called voltage or the potential difference.

E.M.F Shows the reason while potential difference represents the effect.

4. Give comparisons between 1-phase and 3-phase supply.

- In a single-phase connection, the flow of electricity is **through a single conductor.** A three-phase connection, on the other hand, consists **of three separate conductors that are needed for transmitting electricity.**
- In a single-phase power supply system, the **voltage may reach up to 230 Volts.** But on a three-phase connection, it can carry a **voltage of up to 415 Volts.**
- For smooth flow of electricity on a single-phase connection, it requires two separate wires. **One represents the neutral wire and another one represents a single phase.** These are required to complete the circuit. In a three-phase connection, the system requires **one neutral wire and three-phase wires to complete the circuit.**
- **Maximum power gets transmitted on a three-phase connection compared to a single-phase power supply.**
- A single-phase connection consists of two wires that make a simple network. But the network is complicated on a three-phase connection because there are four different wires.
- **Because a single-phase connection has one phase wire, if anything happens to the network, the complete power supply gets interrupted.** However, in a three-phase power supply, if anything happens to a single phase the other phases still work. As such, there is no power interruption.
- Regarding efficiency, a single-phase connection is less compared to a three-phase connection. This is because a three-phase supply needs less conductor compared to a single-phase power supply for the same circuit.





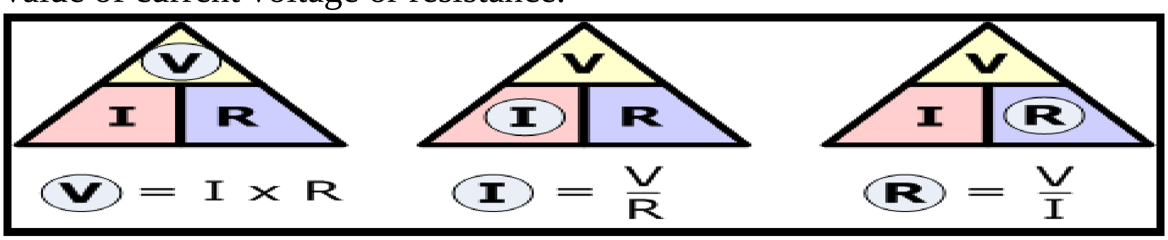
4-MARKS QUESTIONS

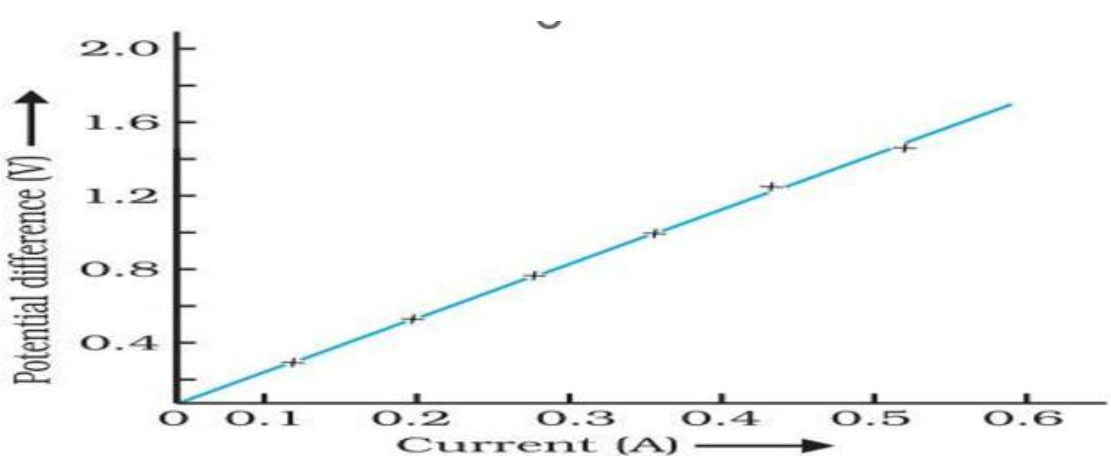
1. State and explain ohm's law with its limitation.

Ohm's law establishes relation between the voltage V applied to a conductor and current I passing through it. It can be given as below:
"If the temperature remains constant, ratio of applied voltage V applied across the conductor and current I flowing through it remains constant.

So, ratio V/I = constant. (Constant is replaced with resistance R).
So, V/I = R. (where V = voltage, I = current and R= resistance).

If in above equation if the value of voltage V= 1 Volt, current I = 1 Amp., the resistance R = 1ohm. So, with the help of ohm's law, we can find the value of current voltage or resistance.





Limitations of Ohm's Law

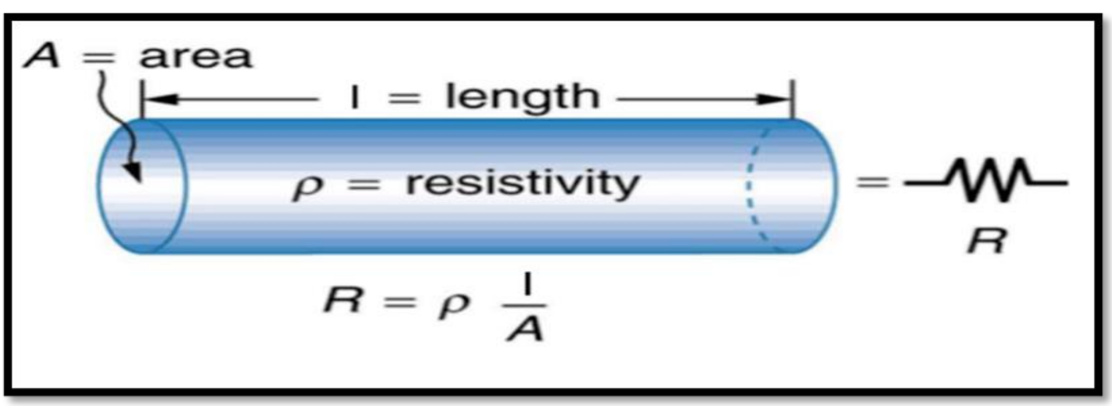
- Ohm's law can be applied only when temperature is constant. Because when temperature changes, resistance changes.
- Ohm's law is not applicable to all materials. For example, the characteristics of semiconductor, silicon carbide etc. are not linear.
- In a.c circuit, Ohm' law can be applied to resistance only. This law cannot be applied to inductor or capacitor.

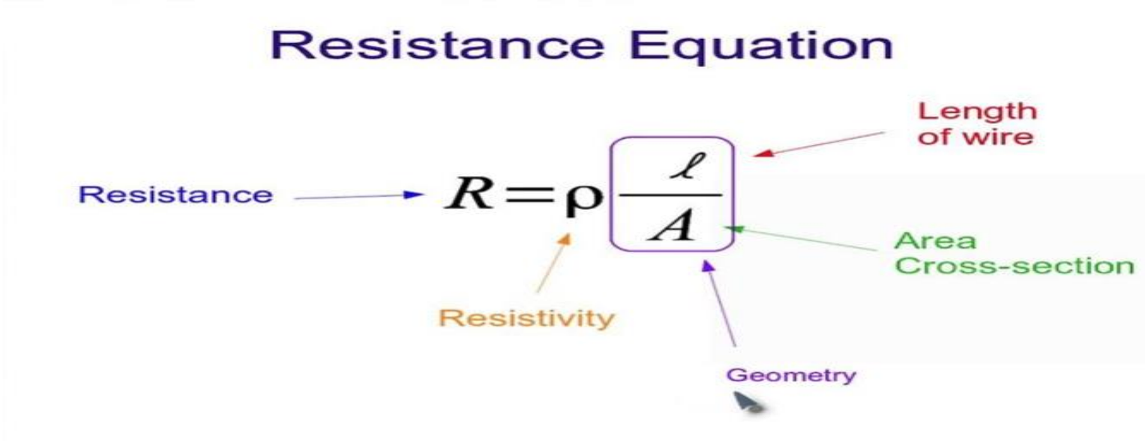
2. State and explain factors affecting the value of electrical resistor.

Resistance id depends upon below mentioned factors.

- **Length of material.**
- **Cross sectional area.**
- **Temperature.**
- **Type of Material.**

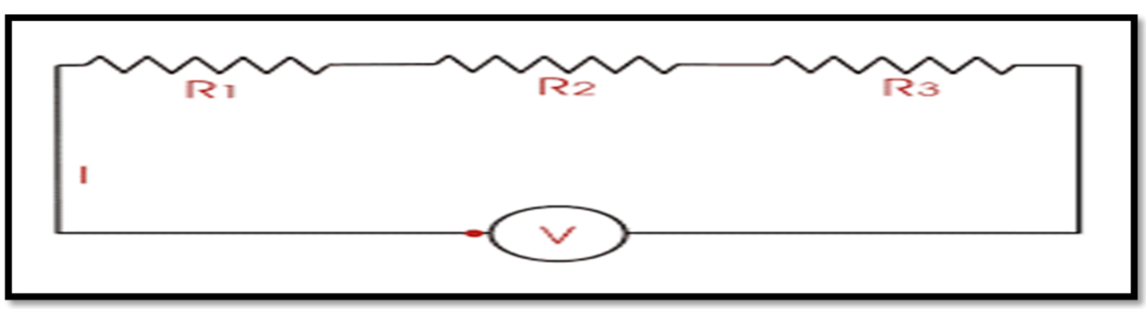
Length of material: Resistance of material increases as length increases.
Cross-sectional area: Resistance is inversely proportional to the cross-sectional area. When area increases resistance decreases and when area decreases, resistance increases.
Temperature: As temperature increase resistance also increases.
Material: Resistance varies according to the types of material e.g., conductor, semi-conductor and insulator.





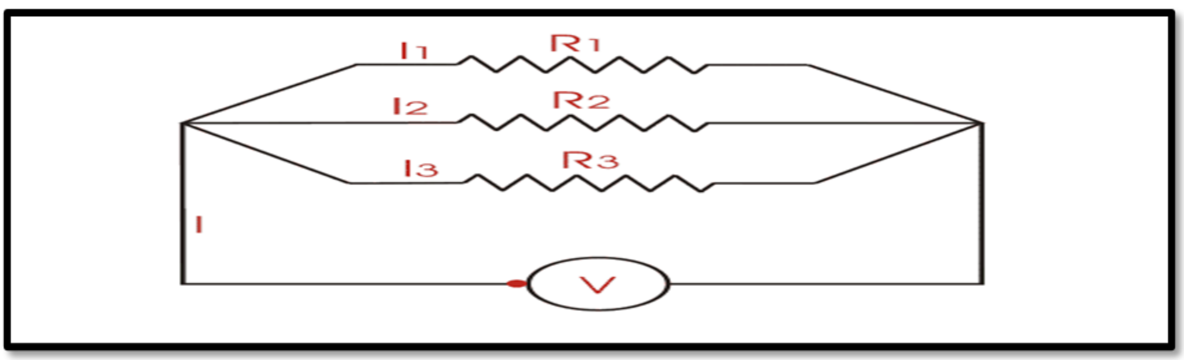
3. Derive the equation of equivalent resistance when "n" number of resistors are connected in series.

- When three resistors are connected in series, then the same current passes through each resistor but the voltage drop is different for each resistor.
- We know that applied voltage is(V)
  ∴V=V1+V2+V3
- we also know that,
  V=I·R (from ohm's law)
  ∴I·Req=I·R1+I·R2+I·R3
  ⇒I·Req=I·(R1+R2+R3)
  ⇒ Req=R1+R2+R3
- It can be extended for n resistors
  Req= R1+R2...................................Rn
- So, the equivalent resistance or the total resistance of the circuit can be defined as a single value of resistance that can replace any number of resistors connected in series without altering the values of the current or the voltage in the circuit.



4. Derive the equation of equivalent resistance when "n" number of resistors are connected in parallel.

- In Parallel connection voltage V is same throughout the circuit.
- Current I is divided between resistors.
- So, in parallel connection,
  CURRENT I = DIVIDED
  AND VOLTAGE V = SAME IN THE CIRCUIT
- **SO, I=I1+I2+I3**
- According to ohm's law
  I=V/R.
- **SO, V/R=V/R1+V/R2+V/R3**
- Take voltage V common from both side we get,
  1/R=1/R1+1/R2+1/R3
- It can be extended for n resistors
  1/R=1/R1+1/R2+1/R3+…………1/Rn



FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

SUBJECT ASSIGNMENT

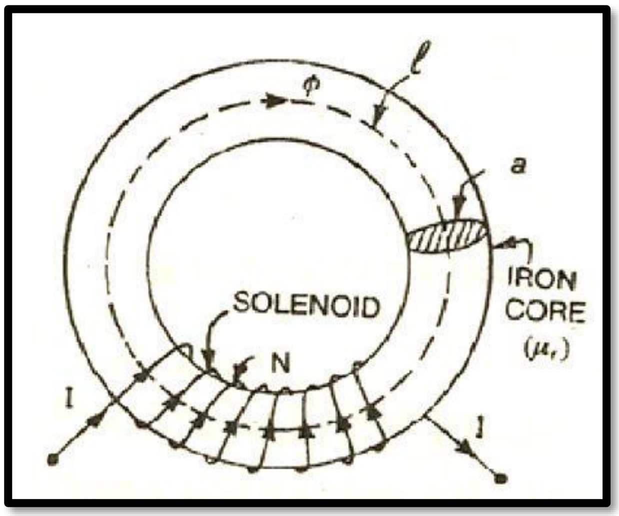
PARUL UNIVERSITY | DIPLOMA STUDIES | ELECTRICAL ENGINEERING DEPATEMENT

CHAPTER-5 MAGNETIC CIRCUIT

2 MARKS QUESTIONS

1. **Draw the magnetic circuit and define magnetic flux.**

   Magnetic Circuit: in fig an iron ring of mean length l meter and cross sectional area of A meter square is shown. The ring wound with a coil of N number of turns. The coil carries current of I ampere. So magnetic flux is produced in the ring.



   Magnetic flux: Magnetic Flux is defined as the number of magnetic field lines passing through a given closed surface. It gives the measurement of the total magnetic field that passes through a given surface area. Here, the area under consideration can be of any size and under any orientation with respect to the direction of the magnetic field.

2. **Define the terms 1) M.M.F 2) Reluctance.**

   M.M.F: just as electromotive force (emf) is necessary to pass current in electric circuit. Magneto motive force (mmf) is necessary to establish flux in the magnetic circuit. Magneto motive force is the multiplication of current flowing through the coil and the number of turns of the coil.

   mmf = I*N.

   unit of magneto motive force is ampere turn and **its symbol is Fm.**

Reluctance: it is the property of the material to oppose the establishment of magnetic flux through it. It is similar to resistance in electric circuit. Just as R= E/I, we have,

Reluctance = mmf / flux.

S = IN / Φ.

its unit is AT / Wb.

3. **Define permeability of a magnetic material.**

Permeability: The property of material to allow the magnetic flux to be produced through it is called permeability.

4. **Define 1) Magnetic field strength 2) Permeance.**

Magnetic Field Strength: it is the magneto motive force per meter length of the magnetic path. It is denoted by letter H and its unit is ampere turn meter.

H = mmf / length.

H = IN / l.

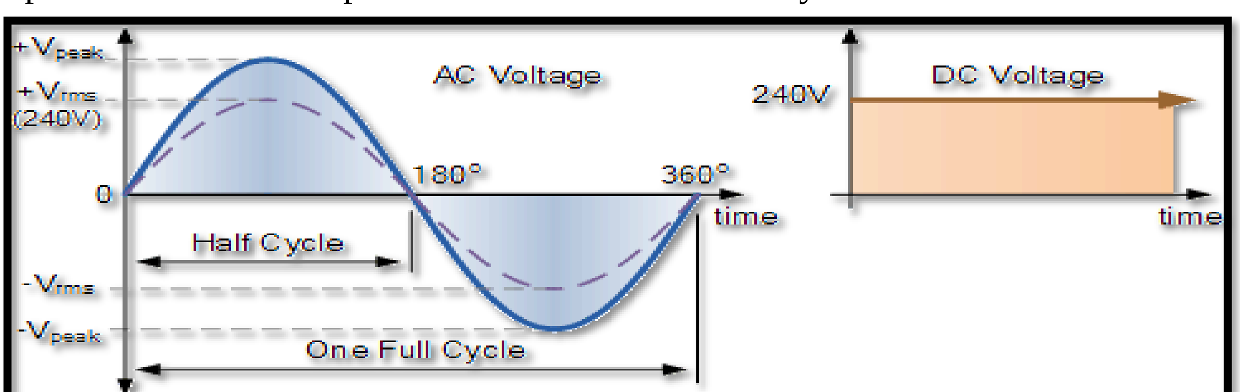
l is the length of the magnetic flux path.

Permeance: it is inverse of reluctance. **Permeance = 1 / Reluctance**. it is denoted by Δ.

Δ = 1 / S.

5. **Define the terms 1) Cycle 2) Frequency.**

Cycle: The emf induced increases from zero in one direction, becomes maximum and then reduce to zero. Afterwards, it increases in opposite direction, becomes maximum and then becomes zero. Afterwards it is repeated. This one complete alternation is called the cycle.



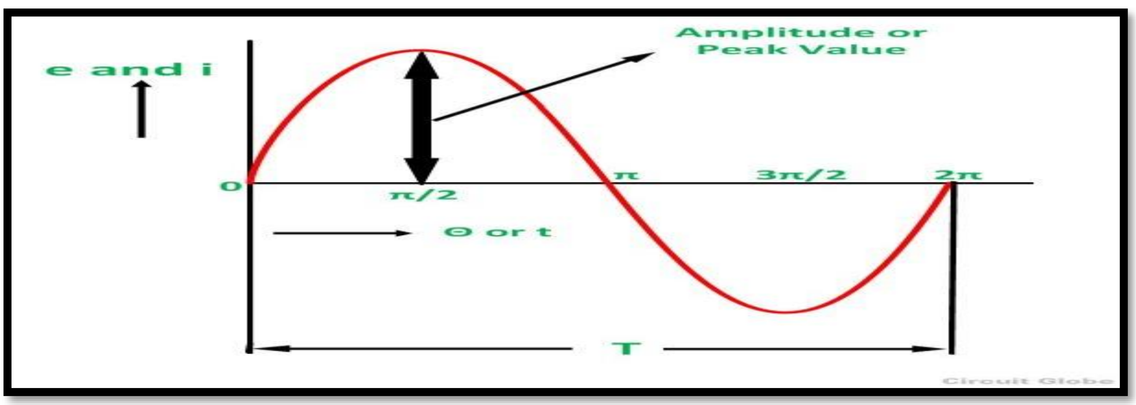
Frequency: it is the number of cycles completed in one second. It is represented by symbol f and its unit is Hertz. in our country frequency used is 50Hz, while in USA it is 60Hz. In electronic oscillators very high frequency is used. it is in the range of KHz and MHz.

$$\boxed{f = \frac{1}{T}}$$

6. **Define the terms 1) Time period 2) Amplitude.**

Time Period: It is the time taken to complete one cycle. It is represented by T and its unit is second.

Amplitude: Maximum value of alternating quantity (emf, current or flux) is called maximum value or peak value or amplitude. In a cycle it occurs twice. One is positive maximum and the other is negative maximum. These two values are equal in magnitude.



7. **Define average value of a.c quantity.**

Average Value: Average value is found by considering the charge transfer. **Average value of electric current is defined as that value of direct current which transfer the same amount of charge in a circuit which is transmitted by an alternating current flowing through the same circuit for the same period.**

The average value is fund by taking the area under the curve and dividing it by the base. Now for alternating waveform the sum of areas becomes zero, as there are two loops of equal area in positive and negative direction. So the average value is found by taking the area of one loop and dividing it by the corresponding base.

I avg = 0.637 Im

8. Define R.M.S value of a.c quantity.

R.M.S Value: We have seen that the value of the alternating quantity changes instantaneously. Its effective value is represented by RMS value. For this heating effect of electric current is taken in to account.

Let us assume that certain value of alternating current flows through a resistor for some period and as a result certain amount of heat is generated. Now we pass direct current through the same value of the resistor for the same time period to produce the same amount of heat. Then this value of direct current is known as effective value or RMS value of the alternating current.

"Thus RMS value of the alternating current is defined as that value of the direct current which is required to be passed through a resistor to produce the same amount of heat produced by the alternating current when passed for the same period through the same value of resistor".

I RMS = 0.707 Im

9. State Lenz's law.

The **induced electromotive force with different polarities induces a current whose magnetic field opposes the change in magnetic flux through the loop in order to ensure that the original flux is maintained through the loop when current flows in it.**

Lenz's Law is reflected in the formula of Faraday's law. Here the negative sign is contributed by Lenz's law. The expression is

$$\boxed{Emf = -N\left(\frac{\Delta\phi}{\Delta t}\right)}$$

Where,

Emf is the induced voltage (also known as electromotive force).

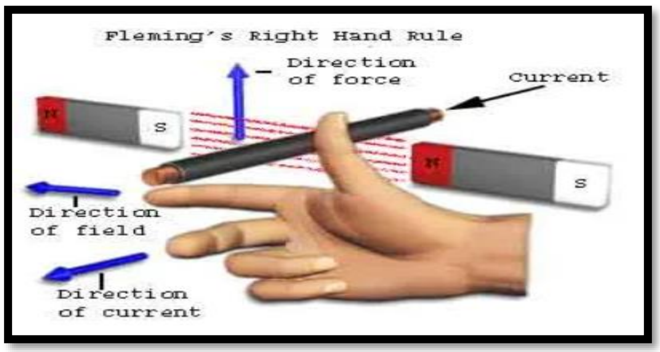
N is the number of loops.

3 MARKS QUESTIONS

1. State and explain Fleming's right-hand rule.

As per Faraday's law of electromagnetic induction, whenever a conductor moves inside a magnetic field, there will be an induced current in it. If this conductor gets forcefully moved inside the magnetic field, there will be a relation between the direction of applied force, magnetic field and the current. This relation among these three directions is determined by Fleming's right-hand Rule.

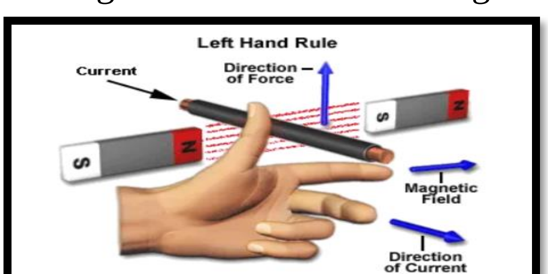
This rule states "Hold out the right hand with the first finger, second finger and thumb at the right angle to each other. If forefinger represents the direction of the line of force, the thumb points in the direction of motion or applied force, then second finger points in the direction of the induced current".

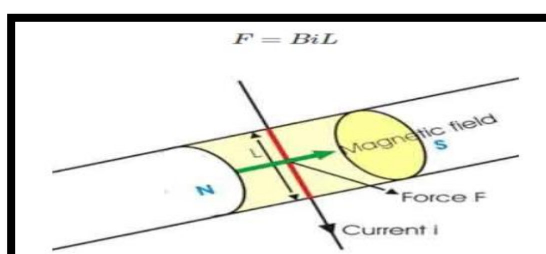


2. State and explain Fleming's left-hand rule.

It is found that whenever a current carrying conductor is placed inside a magnetic field, a force acts on the conductor, in a direction perpendicular to both the directions of the current and the magnetic field.

In the figure below, a portion of a conductor of length 'L' is placed vertically in a uniform horizontal magnetic field of strength 'H', produced by two magnetic poles N and S. If the current 'I' is flowing through this conductor, the magnitude of the force acting on the conductor is:



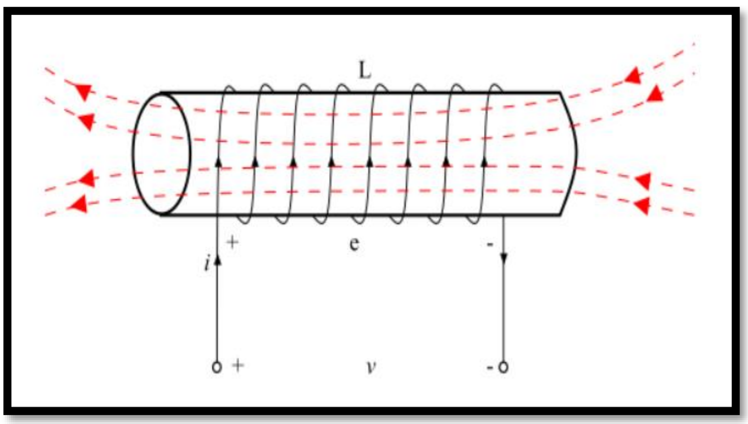


3. Explain statically induced emf.

Statically Induced emf: When the conductor is stationary and the magnetic field is changing, the induced EMF in such a way is known as statically induced EMF (as in a transformer). It is so called because the EMF is induced in a conductor which is stationary. The statically induced EMF can also be classified into two categories.

Self-Induced emf
Mutually Induced EMF

Self-Induced emf: When an EMF is induced in the coil due to the change of its own magnetic flux linked with it is known as self-induced EMF.
When a current flow in a coil, a magnetic field produced by this current through the coil. If the current in the coil changes, then the magnetic field linking the coil also changes. Therefore, according to Faraday's law of electromagnetic induction, an EMF being induced in the coil. The induced EMF in such a way is known as self-induced EMF.
Mathematically, self-induced EMF is given by,

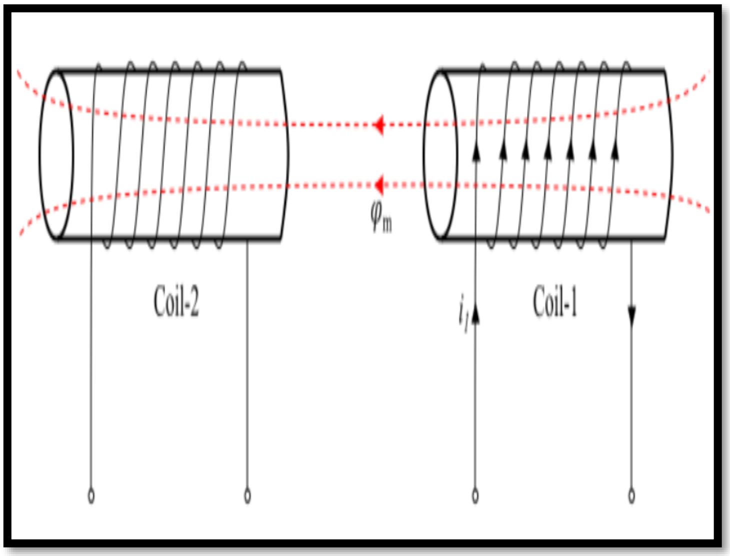


$$e = L\frac{di}{dt}$$

Where, L is the self-inductance of the coil.

Mutually Induced emf: When an EMF is induced in a coil due to changing magnetic flux of neighboring coil is known as mutually induced EMF.
Consider two coils coil-1 and coil-2 placed adjacent to each other (see the figure). A fraction of the magnetic flux produced by coil-1 links with the coil-2. This magnetic flux which is common to both the coils 1 and 2 is known as mutual flux. Now, if the current in coil-1 changes, the mutual flux also changes and thus EMF being induced in both the coils. The EMF induced in

coil-2 is known as mutually induced EMF, since it is induced due changing in flux which is produced by coil-1. Mathematically, the mutually induced EMF is given by,

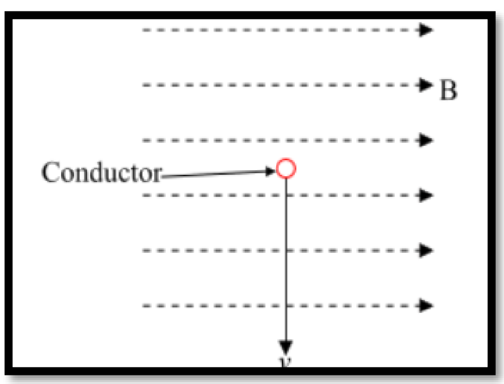


$$e_m = M\frac{di_1}{dt}$$

Where, M is the mutual inductance between the coils.

4. Explain dynamically induced emf.

When the conductor is moved in a stationary magnetic field so that the magnetic flux linking with it changes in magnitude, as the conductor is subjected to a changing magnetic, therefore an EMF will be induced in it. The EMF induced in this way is known as dynamically induced EMF (as in a DC or AC generator). It is so called because EMF is induced in a conductor which is moving (dynamic).



Consider a conductor of length l meters moving with a velocity of v m/s at right angles to a uniform stationary magnetic field of flux density B Wb/m2.

Let the conductor moves through a small distance dx in time dt seconds. Then,

Area swept by conductor, $a = l \times dx$ m^2

$\therefore$ Magnetic flux cut by conductor, $d\psi =$ Magnetic Flux Density $\times$ Area Swept

$\Longrightarrow d\psi = B\,l\,dx$ Wb

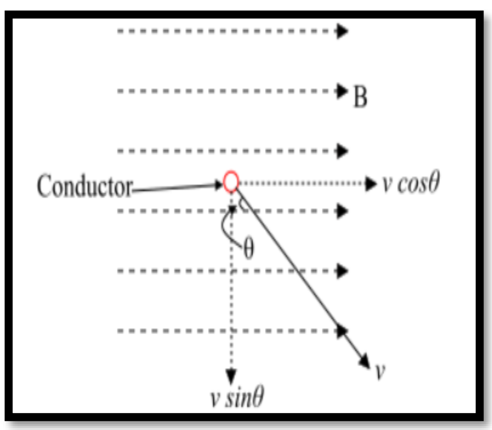
Now, according to Faraday's law of electromagnetic induction, the induced EMF will be

$$e = N\frac{d\psi}{dt} = \frac{B\,l\,dx}{dt} \quad (\because N = 1)$$

$$\because \frac{dx}{dt} = \text{Velocity } V$$

$$\boxed{\therefore e = B\,l\,v \text{ Volts}}$$

Equation gives the dynamically induced EMF when the conductor moves at right angle to the magnetic field.



If the conductor moves at an angle &theta to the magnetic field, then the EMF induced due to only the perpendicular component of the velocity to the magnetic field.

$$\boxed{e = B\,l\,v\,\sin\theta}$$

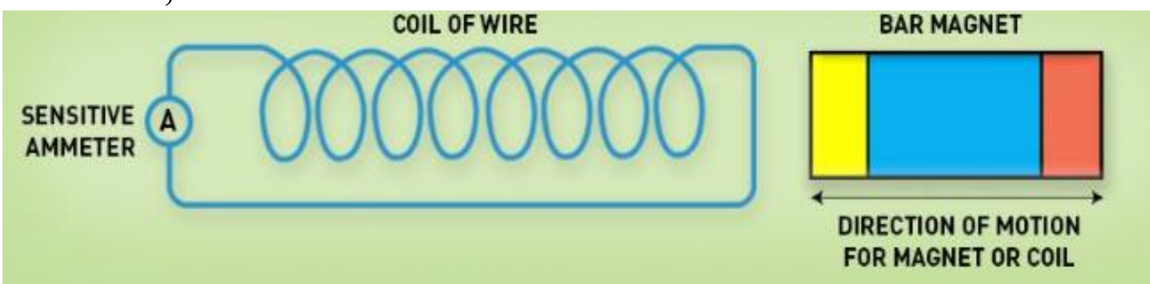
4 MARKS QUESTIONS

1. State and explain Faraday's law of electromagnetic induction.

Faraday's Laws of Electromagnetic Induction consists of two laws. The first law describes the induction of emf in a conductor and the second law quantifies the emf produced in the conductor.

1st law: The discovery and understanding of electromagnetic induction are based on a long series of experiments carried out by Faraday and Henry. From the experimental observations, Faraday concluded that an emf is induced when the magnetic flux across the coil changes with time. Therefore, Faraday's first law of electromagnetic induction states the following:

"Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced. If the conductor circuit is closed, a current is induced, which is called induced current".



Mentioned here are a few ways to change the magnetic field intensity in a closed loop:

- By rotating the coil relative to the magnet.
- By moving the coil into or out of the magnetic field.
- By changing the area of a coil placed in the magnetic field.
- By moving a magnet towards or away from the coil.

2nd law: The induced emf in a coil is equal to the rate of change of flux linkage.

Primary flux linkage = Nϕ1

Secondary flux linkage= Nϕ2

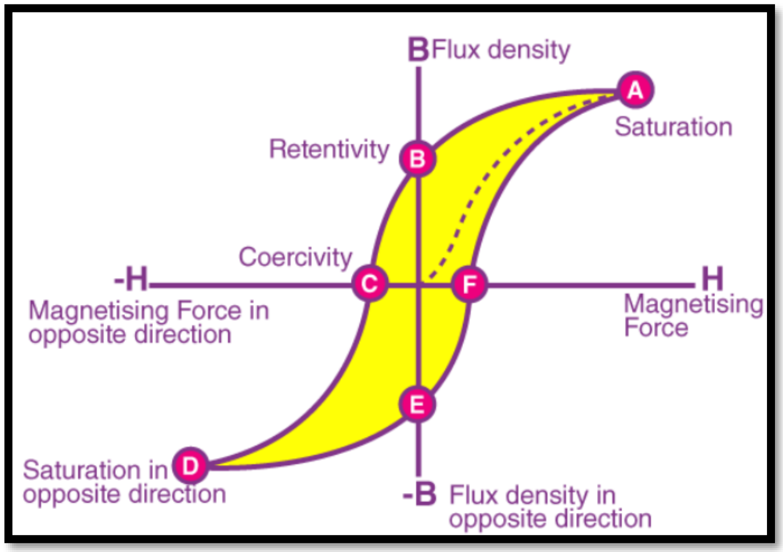
E.m.f induced = Nϕ2-Nϕ1/ t (time)

= N (ϕ2-ϕ1) / t (time)

$$\boxed{\varepsilon = -N\frac{\Delta\Phi}{\Delta t}}$$

2. **Draw and explain Hysteresis loop (B-H Curve).**

- The hysteresis loop shows the relationship between the magnetic flux density and the magnetizing field strength. The loop is generated by measuring the magnetic flux coming out from the ferromagnetic substance while changing the external magnetizing field.



- **Looking at the graph, if B is measured for various values of H and if the results are plotted in graphic forms then the graph will show a hysteresis loop.**
- The magnetic flux density (B) is increased when the magnetic field strength(H) is increased from 0 (zero).
- With increasing the magnetic field there is an increase in the value of magnetism and finally reaches point A which is called saturation point where B is constant.
- With a decrease in the value of the magnetic field, there is a decrease in the value of magnetism. But at B and H are equal to zero, substance or material retains some amount of magnetism is called retentively or residual magnetism.
- When there is a decrease in the magnetic field towards the negative side, magnetism also decreases. At point C the substance is completely demagnetized.
- The force required to remove the retentively of the material is known as Coercive force (C).
- In the opposite direction, the cycle is continued where the saturation point is D, retentively point is E and coercive force is F.

- Due to the forward and opposite direction process, the cycle is complete and this cycle is called the hysteresis loop.

3. Give comparison between electric and Magnetic circuit.

Electric Circuit	Magnetic Circuit
The closed path foe electric current is called electric circuit.	The closed path for magnetic flux is called a magnetic circuit.
Current flows through the conductor. Unit of current is ampere.	Flux is produced in the material. Unit of flux is Weber.
Electromotive force (emf) is necessary to force current to flow in electric circuit. Its unit is volt.	Magneto motive force (mmf) is necessary to produce flux in the material. Its unit is ampere turn.
Property of material to oppose the flow of electric current is called resistance. Its unit is ohm.	Property of material to oppose the establishment of magnetic flux is called reluctance. Its unit is AT/Wb.
Conductance = 1/ resistance	Permeance = 1/ reluctance.
There is resistivity of material.	There is reluctivity of material.
Conductivity = 1 / resistivity	Permeability = 1 / reluctivity.
Current = emf / resistance.	Flux = mmf/ reluctance.

FUNDAMENTALS OF ELECTRICAL AND ELECTRONICS ENGINEERING

CHAPTER-6 SOLUTION

PARUL UNIVERSITY

DIPLOMA STUDIES

ELECTRICAL ENGINEERING DEPATEMENT

CHAPTER-6 TRANSFORMER AND MACHINES

2 MARKS QUESTIIONS

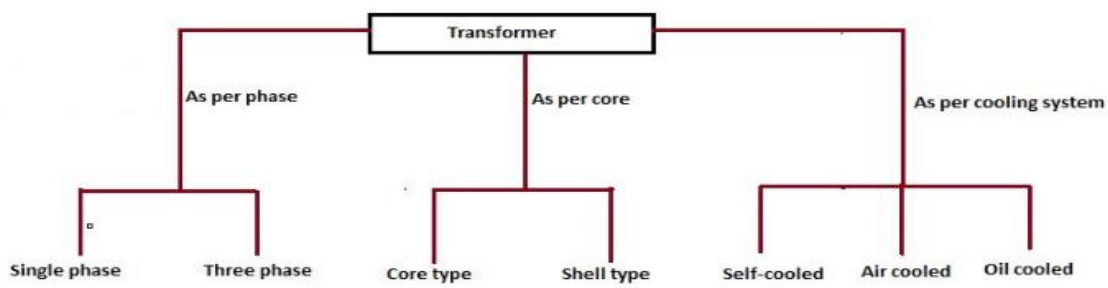
1. **Define transformer.**

   A transformer is a device used in the power transmission of electric energy. The transmission current is AC. It is commonly used to increase or decrease the supply voltage without a change in the frequency of AC between circuits. The transformer works on basic principles of electromagnetic induction and mutual induction.

2. **State the types of transformers.**

   Transformers are used in various fields like power generation grid, distribution sector, transmission and electric energy consumption. There are various types of transformers which are classified based on the following factors;

   - Working voltage range.
   - The medium used in the core.
   - Winding arrangement.
   - Installation location.



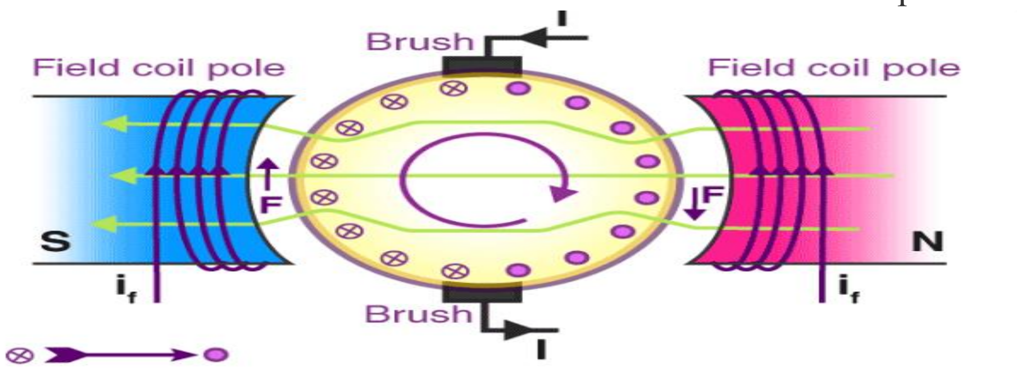
3. **Give working principle of Induction motor.**

   Induction Motors are the most commonly used motors in many applications. These are also called as Asynchronous Motors, because an induction motor always runs at a speed lower than synchronous speed. Synchronous speed means the speed of the rotating magnetic field in the stator.

There basically 2 types of induction motor depending upon the type of input supply - (i) Single phase induction motor and (ii) Three phase induction motor.

4. Give working principle of d.c motor.

A magnetic field arises in the air gap when the field coil of the DC motor is energized. The created magnetic field is in the direction of the radii of the armature. The magnetic field enters the armature from the North pole side of the field coil and "exits" the armature from the field coil's South pole side.



Production of torque in a DC motor

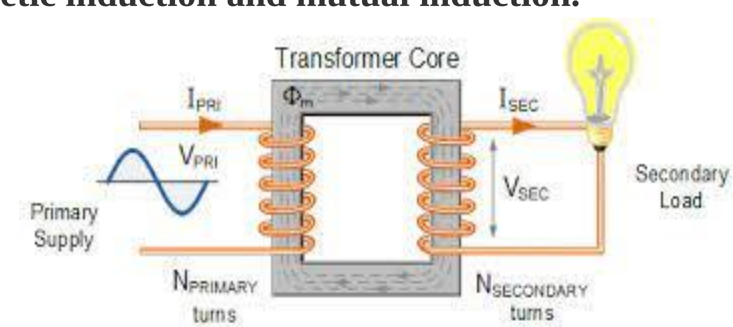
The conductors located on the other pole are subjected to a force of the same intensity but in the opposite direction. These two opposing forces create a torque that causes the motor armature to rotate.

"When kept in a magnetic field, a current-carrying conductor gains torque and develops a tendency to move. In short, when electric fields and magnetic fields interact, a mechanical force arises. This is the principle on which the DC motors work".

3 MARKS QUESTONS

1. Explain working principle of a 1-phase transformer.

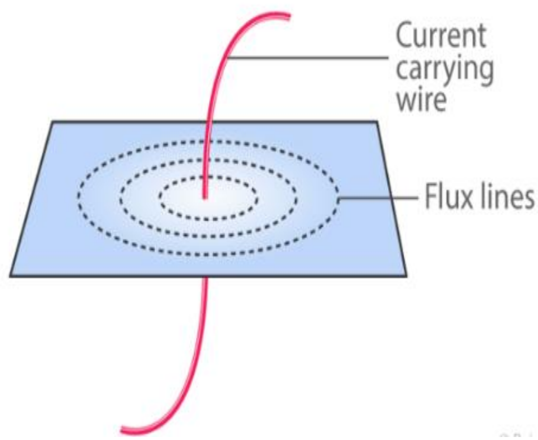
The transformer works on the principle of Faraday's law of electromagnetic induction and mutual induction.



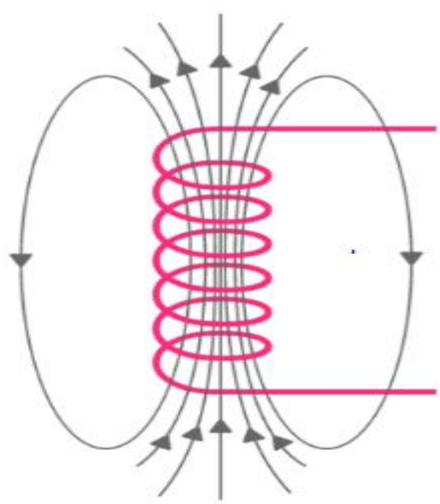
There are usually two coils primary coil and secondary coil on the transformer core. The core laminations are joined in the form of strips. The two coils have high mutual inductance. When an alternating current pass through the primary coil it creates a varying magnetic flux. As per faraday's law of electromagnetic induction, this change in magnetic flux induces an emf (electromotive force) in the secondary coil which is linked to the core having a primary coil. This is mutual induction.

Overall, a transformer carries the below operations:

- Transfer of electrical energy from circuit to another.
- Transfer of electrical power through electromagnetic induction.
- Electric power transfer without any change in frequency.
- Two circuits are linked with mutual induction.



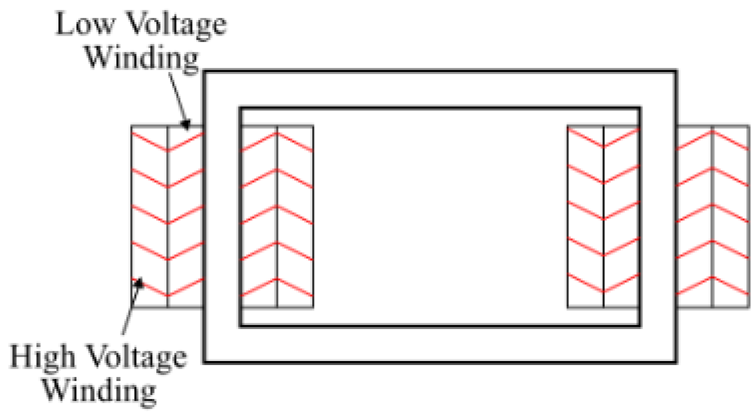
The figure shows the formation of magnetic flux lines around a current-carrying wire. The normal of the plane containing the flux lines are parallel to normal of a cross-section of a wire.



The figure shows the formation of varying magnetic flux lines around a wire-wound. The interesting part is that reverse is also true, when a magnetic flux line fluctuates around a piece of wire, a current will be induced in it. This was what Michael faraday found in 1831 which is the fundamental working principle of electric generators as well as transformers.

2. Draw and explain core type transformer.

In core type construction of the transformer, the magnetic core consists of two vertical lags called limbs and two horizontal sections called yokes. In order to reduce the leakage flux to its minimum value, half of each winding is placed on each lag of the core (see the figure).



The low voltage (lv) winding is placed next to the core and the high voltage (hv) winding is placed around the low voltage winding. This reduces the requirement of insulating material. Hence, the primary and secondary windings are arranged as concentric coils, thus known as concentric winding or cylindrical winding.

The core type construction of transformer is easier to dismantle for maintenance. The natural cooling is good in the core type transformer. Therefore, core type transformers are suitable for high voltage and small output applications.

Advantages

- It offers good mechanical strength.
- It has the advantage of preventing condensed flux leakage and iron loss.
- It is efficient for high frequencies.

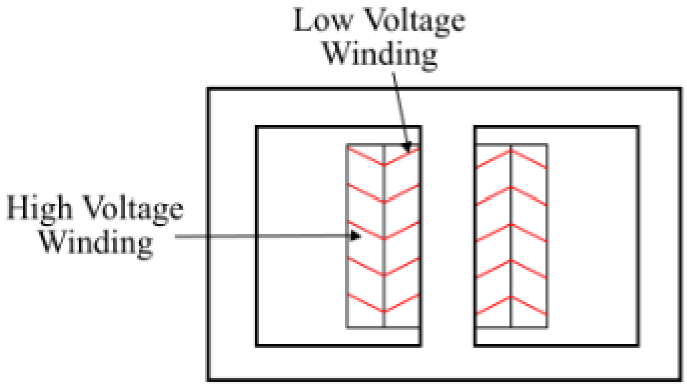
Disadvantages

- It is not good to use outdoors.

- It can be noisy.

3. Draw and explain shell type transformer.

In the shell type construction of the transformer, the magnetic core consists of three vertical lags and two horizontal sections. Both the primary and secondary windings are wound on the central limb and the two outer limbs provide the low reluctance flux path (see the figure).



Therefore, the shell type construction involves the use of a double magnetic circuit. The low voltage (lv) winding is placed next to the core (on the central limb) and around the low voltage winding the high voltage (hv) winding is placed. This arrangement reduces the requirement of insulating material.

The shell type construction of the transformer provides better support against the electromagnetic forces between the current carrying conductors, which are very high under short circuit conditions.

In shell type transformers, a shorter magnetic path is available, hence it requires a small magnetizing current. The natural cooling is poor in shell type transformer, because the coils are placed on the central limb. The shell type transformers are mainly used in low voltage and high output applications.

Advantages

- In shell type transformer core losses or iron losses are less.
- In shell type transformer efficiency is high.
- In shell type transformer less copper conductor required for construction so cost of transformer is less.

Disadvantages

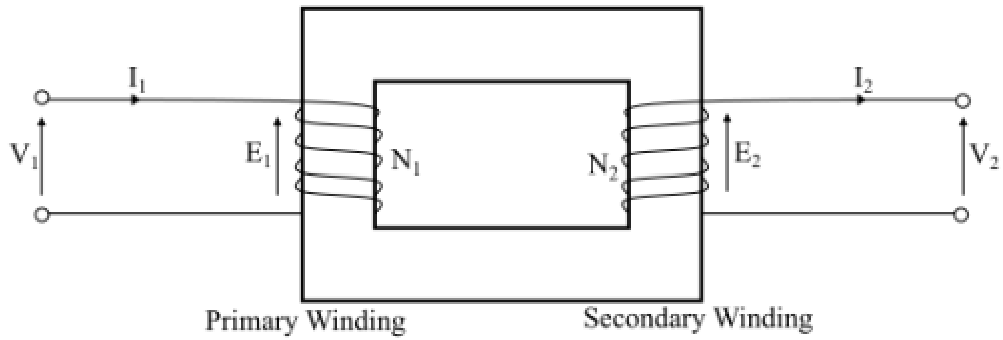
- In shell type transformer, maintenance job of windings is very hard.
- In shell type transformer, heat dissipation is not easy.
- In shell type transformer more insulation required.

- In shell type transformer natural cooling is not possible.

4. Explain turns ration of a 1-phase transformer.

The turn ratio of a single phase transformer is defined as the ratio of number of turns in the primary winding to the number of turns in the secondary winding, i.e.

$$\text{Turn Ratio} = \frac{\text{Number of Primary Turns}(N_1)}{\text{Number of Secondary Turns}(N_2)}$$



Since for a transformer, the voltage per turn being equal in both primary and secondary windings, therefore,

$$\frac{E_1}{N_1} = \frac{E_2}{N_2}$$

$$\Rightarrow \frac{E_1}{E_2} = \frac{N_1}{N_2} = \text{Turn Ratio}$$

Also, if the given transformer is an ideal one, then E1 = V1 and E2 = V2, thus,

$$\text{Turn Ratio} = \frac{N_1}{N_2} = \frac{E_1}{E_2} = \frac{V_1}{V_2}$$

In case of ideal transformer, the input volt-ampere is equal to output volt-ampere, i.e.

$$V_1 I_1 = V_2 I_2$$

$$\Rightarrow \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

$$\text{Turn Ratio} = \frac{N_1}{N_2} = \frac{E_1}{E_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$$

4 MARKS QUESTIONS

1. **Derive e.m.f equation of a 1-phase transformer.**

Primary side of a transformer is connected with an alternating source, hence the current flowing in the primary coil is sinusoidal. The flux generated by this current is also sinusoidal and we can write it as,

$$\emptyset = \emptyset_m \sin \omega t \qquad (1)$$

According to faraday's law the induced emf can be written as

$$e = -\frac{d}{dt}(\emptyset T)$$

$$= -T\frac{d\emptyset}{dt}$$

$$= -T\frac{d}{dt}(\emptyset_m \sin \omega t)$$

$$= -T\omega\emptyset_m \cos \omega t$$

As we can write cosωt as sin (pi/2 – ωt) but as we can see there is negative sign in the above equation it will be modified like this

$$e = T\omega\emptyset_m \sin\left(\omega t - \frac{\pi}{2}\right) \qquad (2)$$

Equation (2) may be written as

$$e = E_m \sin\left(\omega t - \frac{\pi}{2}\right) \qquad (3)$$

Where $E_m = T\omega\emptyset_m$ it is the maximum value of induced emf.

For a sine wave, the r.m.s value of the e.m.f. is given by

$$E_{rms} = E = {E_m}/{\sqrt{2}}$$

$$E = \frac{T\omega\emptyset_m}{\sqrt{2}} = \frac{T(2\pi f)\emptyset_m}{\sqrt{2}}$$

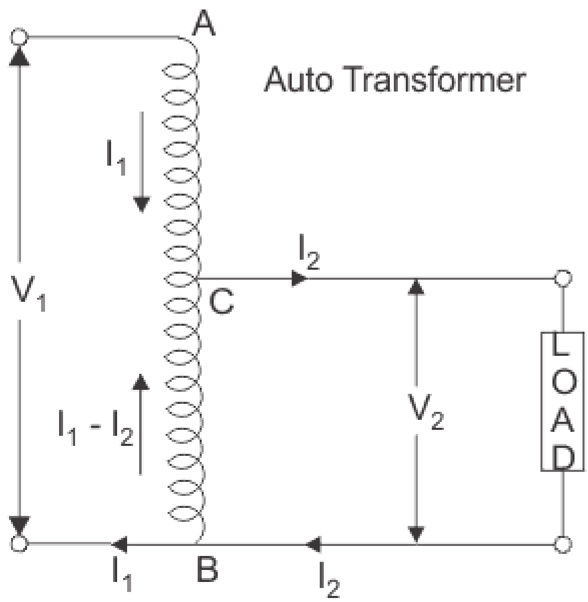
Or $$E = 4.44\emptyset_m fT \qquad (4)$$

Equation (1.2.4) is called the e.m.f. equation of a transformer.

2. Write short note on "Auto-transformer".

An **autotransformer** (or **auto transformer**) is a type of electrical transformer with only one winding. The "auto" prefix refers to the single coil acting alone (Greek for "self") – not to any automatic mechanism. An auto transformer is similar to a two winding transformer but varies in the way the primary and secondary winding of the transformer are interrelated.

In an auto transformer, one single winding is used as primary winding as well as secondary winding. But in two windings transformer two different windings are used for primary and secondary purpose. A circuit diagram of auto transformer is shown below.



The winding AB of total turns N1 is considered as primary winding. This winding is tapped from point ′C′ and the portion BC is considered as secondary. Let's assume the number of turns in between points ′B′ and ′C′ is N2.

If V1 voltage is applied across the winding i.e. in between ′A′ and ′C′.

$$So\ voltage\ per\ turn\ in\ this\ winding\ is\ \frac{V_1}{N_1}$$

Hence, the voltage across the portion BC of the winding, will be,

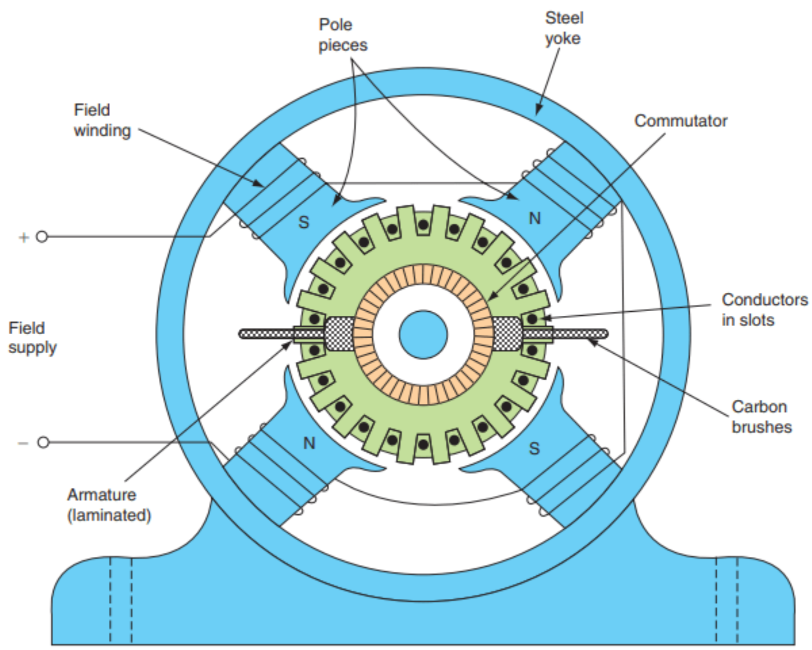
$$\frac{V_1}{N_1} X N_2\ and\ from\ the\ figure\ above,\ this\ voltage\ is\ V_2$$

$$Hence,\ \frac{V_1}{N_1} X N_2 = V_2$$

$$\Rightarrow \frac{V_2}{V_1} = \frac{N_2}{N_1} = Constant = K$$

As BC portion of the winding is considered as secondary, it can easily be understood that value of constant ′k′ is nothing but turns ratio or voltage ratio of that **auto transformer**. When load is connected between secondary terminals i.e. Between ′B′ and ′C′, load current I2 starts flowing. The current in the secondary winding or common winding is the difference of I2 and I1.

3. Draw the construction of D.C Motor and explain any three parts of it.



The dc generators and dc motors have the same general construction. In fact, when the machine is being assembled, the workmen usually do not know whether it is a dc generator or motor.

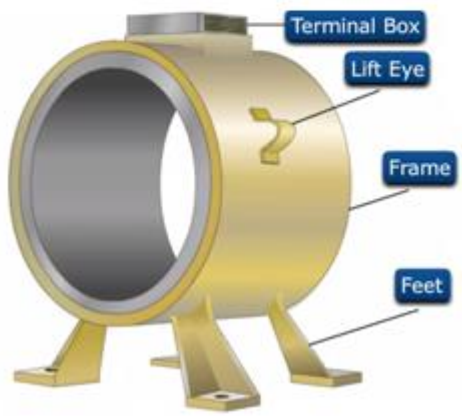
Any dc generator can be run as a dc motor and vice-versa. In this article, we will explain the construction of dc machine in detail.

<u>All dc machines have five principal components</u>

- Magnetic frame or Yoke
- Pole Cores and Pole Shoes
- Pole Coils or Field Coils
- Armature core
- Armature Winding
- Commutator
- Brushes and Bearings

1. **<u>Yoke (Magnetic Frame):</u>** The outer frame or yoke serves a double purpose:
   - It provides mechanical support for the poles and acts as a protecting cover for the whole machine.
   - It carries the magnetic flux produced by the poles.

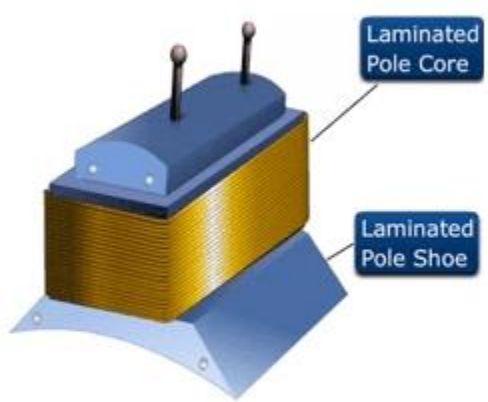
   In **small generators** where cheapness rather than weight is the main consideration, yokes are made of **cast iron**. But for **large machines usually cast steel or rolled steel** is employed.



- The modern process of forming the yoke consists of rolling a steel slab around a cylindrical mandrel and then welding it at the bottom.
- The feet and the terminal box etc. are welded to the frame afterward. Such yokes possess sufficient mechanical strength and have high permeability.

2. **Pole cores and pole shoes:** The field magnets consist of **pole cores and pole shoes**. The pole shoes serve two purposes:

    - they spread out the flux in the air gap and also, being of larger cross-section, reduce the reluctance of the magnetic path.
    - they support the exciting coils (or field coils).

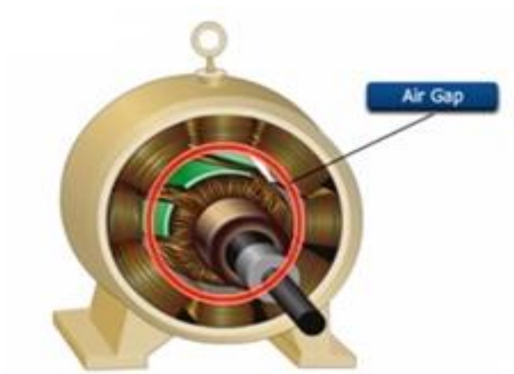


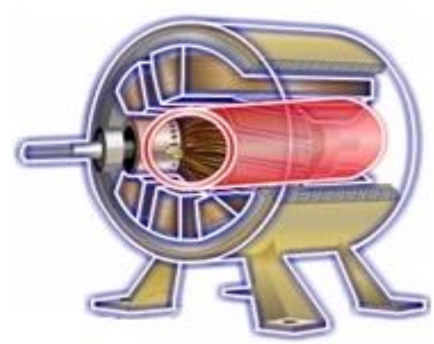
There are two main types of pole construction.

- The pole core itself may be a solid piece made out of either cast iron or cast steel but the pole shoe is laminated and is fastened to the pole face by means of countersunk screws.

- In modern design, the complete pole cores and pole shoes are built of thin laminations of annealed steel which are riveted together under hydraulic pressure. The thickness of laminations varies from 1 mm to 0.25 mm.

3. **Field System:** The function of the field system is to produce a uniform magnetic field within which the armature rotates.
    - Field coils are mounted on the poles and carry the dc exciting current. The field coils are connected in such a way that adjacent poles have opposite polarity.
    - The mmf developed by the field coils produces a magnetic flux that passes through the pole pieces, the air gap, the armature, and the frame.
    - Practical dc machines have air gaps ranging from 0.5 mm to 1.5 mm.





- Since armature and field systems are composed of materials that have high permeability, most of the m.m.f. of field coils is required to set up flux in the air gap.
- By reducing the length of the air gap, we can reduce the size of field coils (i.e. the number of turns).