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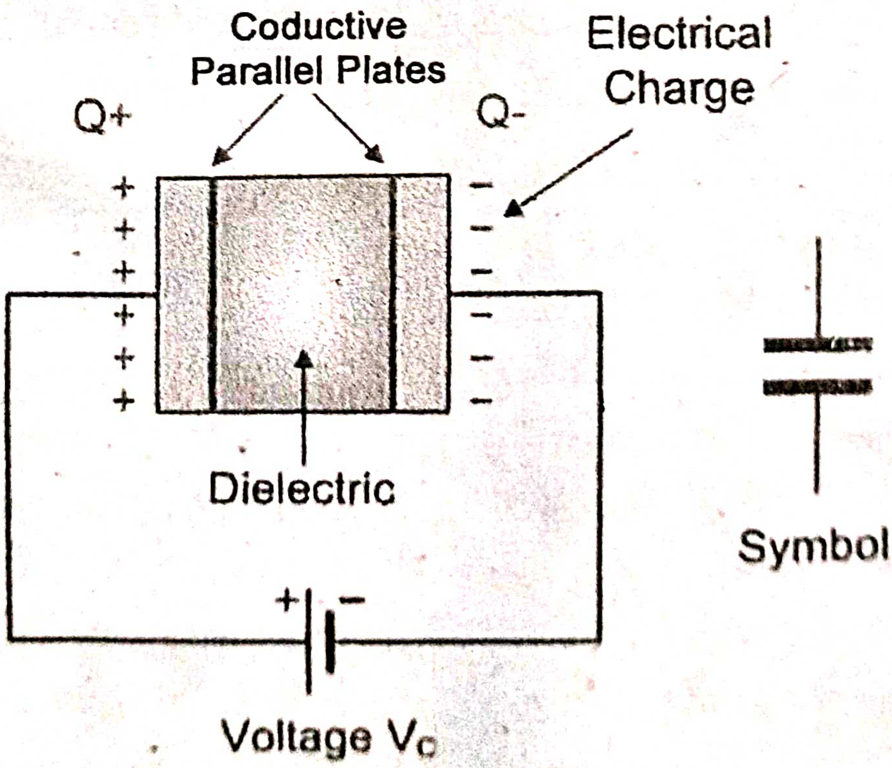
UNIT - I

ESSAY QUESTIONS

Q. 1. *What is capacitance and explain about capacitor.*

Capacitance is a property of an electric conductor that is measured by the amount of separated electric charge that can be stored on it per unit charge in electrical potential.

Capacitance also implies an associated storage of electrical energy. If electric charge is transferred between two initially uncharged conductors, both become equally charged, one positively, the other negatively, and a potential difference is established between them. The capacitance C is the ratio of the amount of charge q on either conductor to the potential difference V between the conductors, or simply $C = q/V$.



The unit of electric charge is coulomb and the unit of potential difference is volt, so that the unit of capacitance named farad is one coulomb per volt.

A capacitor is a device which stores electric charge. Capacitors vary in shape and size, but the basic configuration is two conductors carrying equal but opposite charges.

Capacitors have many important applications in electronics. Some examples include storing electric potential energy, delaying voltage changes when coupled with resistors, filtering out unwanted frequency signals, forming resonant circuits and making frequency-dependent and independent voltage dividers when combined with resistors.

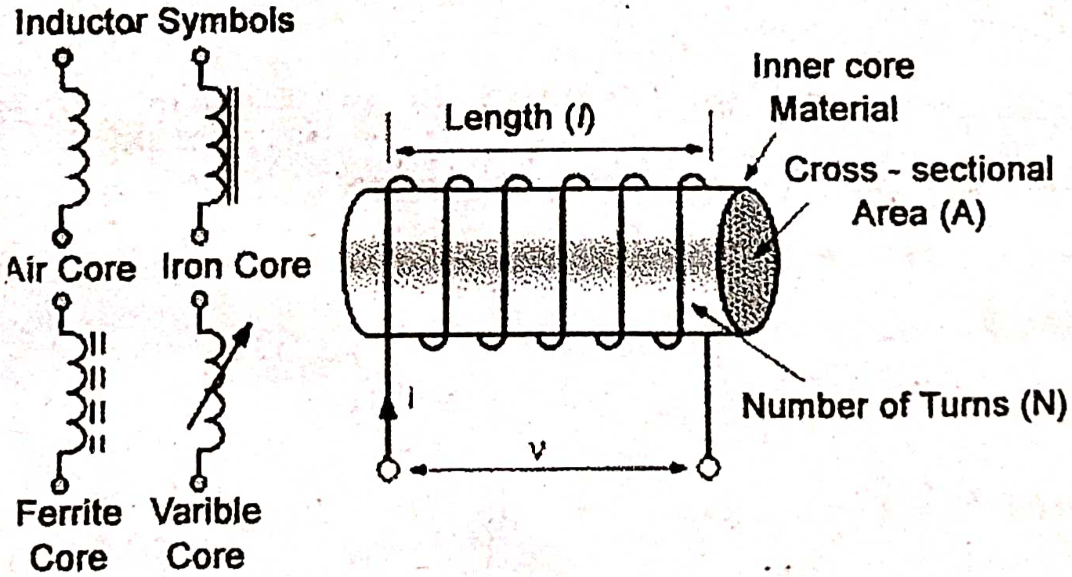
Q. 2. What is inductance and explain about Inductor.

Inductance is the property of an electric conductor or circuit that causes an electromotive force to be generated by a change in the current flowing.

In electromagnetism and electronics, inductance is the tendency of an electrical conductor to oppose a change in the electric current flowing through it. The flow of electric current creates a magnetic field around the conductor. The field strength depends on the magnitude of the current, and follows any changes in current. From Faraday's law of induction, any change in magnetic field through a circuit induces an electromotive force (EMF) in the conductors, a process known as electromagnetic induction. This induced voltage created by the changing current has the effect of opposing the change in current. This is stated by Lenz's law, and the voltage is called *back EMF.*

Inductance is defined as the ratio of the induced voltage to the rate of change of current causing it. It is a proportionality factor that depends on the geometry of circuit conductors and the magnetic permeability of nearby materials. An electronic component designed to add inductance to a circuit is called an inductor.

Inductors are components that are simple in their construction, consisting of coils of insulated copper wire wound around a former that will have some type of core at its centre. This core might be a metal such as iron that can be easily magnetized or in high frequency inductors, it will more likely to be just air.



Inductors are extensively used in alternating current (AC) applications such as radio, TV and communications equipment, and in these systems, how inductors react to AC signals of different frequencies is very useful.

Q. 3. *Explain about electric conductors, insulators and give some examples.*

Electric Conductors :

Electric Conductors are the materials or substances which allow electricity to flow through them. They conduct electricity because they allow electrons to flow easily inside them from atom to atom.

The behavior of an object that has been charged is dependent upon whether the object is made of a conductive or a non-conductive material. Conductors are materials that permit electrons to flow freely from particle to particle. An object made of a conducting material will permit charge to be transferred across the entire surface of the object. If charge is transferred to the object at a given location, that charge is quickly distributed across the entire surface of the object. The distribution of charge is the result of electron movement. Since conductors allow for electrons to be transported from particle to particle, a charged object will always distribute its charge until the overall repulsive forces between excess electrons is minimized.

Examples of Conductors :

(1) Material such as silver is the best conductor of electricity. But, it is costly and so, we don't use silver in industries and transmission of electricity.

(2) Copper, Brass, Steel, Gold, and Aluminum are good conductors of electricity. We use them in electric circuits and systems in the form of wires.

(3) Mercury is an excellent liquid conductor. Thus, this material finds use in many instruments.

(4) Gases are not good conductors of electricity because the atoms are quite far away. Thus, they are unable to conduct electrons.

Electric Insulators :

Insulators are the materials or substances which resist the current to flow through them. In general, they are solid in nature. Also, insulators are finding use in a variety of systems. The property which makes insulators different from conductors is its resistivity.

Insulators are materials that impede the free flow of electrons from atom to atom and molecule to molecule. If charge is transferred to an insulator at a given location, the excess charge will remain at the initial location of charging. The particles of the insulator do not permit the free flow of electrons subsequently charge is seldom distributed evenly across the surface of an insulator.

Examples of Insulators :

(1) Glass is the best insulator as it has the highest resistivity.

(2) Plastic is a good insulator and it finds its use in making a number of things.

(3) Rubber is a common material used in making fire-resistant clothes and slippers. This is because it is a very good insulator.

Q. 4. *What is ohm's law give applications and limitations of ohm's law.*

Ohm's Law states that the current flowing through a conductor is directly proportional to the potential difference applied across its ends, provided the temperature and other physical conditions remain unchanged. Mathematically it can be represented as

$$\text{Potential difference} \propto \text{Current}$$

$$V \propto I$$

$$V = IR$$

Where,

V is Voltage in volts (V)

R is Resistance in ohm (Ω)

I is Current in Ampere (A)

Different Applications of Ohm's Law :

1. To determine the voltage, resistance or current of an electric circuit.
2. Ohm's law is used to maintain the desired voltage drop across the electronic components.
3. Ohm's law is also used in dc ammeter and other dc shunts to divert the current.

Limitations of Ohm's Law :

1. Ohm's law is not applicable for unilateral electrical elements like diodes and transistors as they allow the current to flow through in one direction only.
2. For non-linear electrical elements with parameters like capacitance, resistance etc the voltage and current won't be constant with respect to time making it difficult to use Ohm's law.

Q. 5. Explain construction and working of Galvanometer.

A galvanometer is a device that is used to detect small electric current or measure its magnitude. The current and its intensity is usually indicated by a magnetic needle's movement or that of a coil in a magnetic field that is an important part of a galvanometer.

Moving-coil galvanometers are mainly divided into two types :

(1) Suspended coil galvanometer

(2) Pivoted-coil or Weston galvanometer

Principle of Moving Coil Galvanometer :

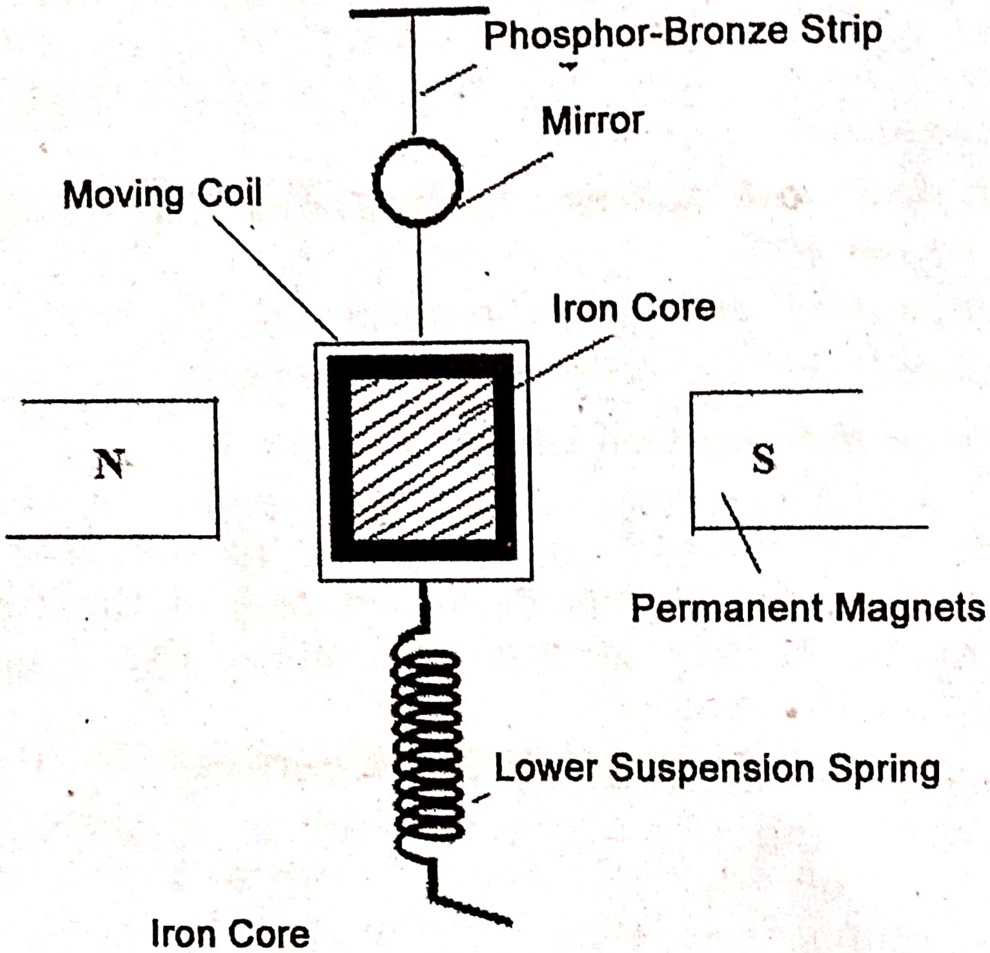
A current carrying coil when placed in an external magnetic field experiences magnetic torque. The angle through which the coil is deflected due to the effect of the magnetic torque is proportional to the magnitude of current in the coil.

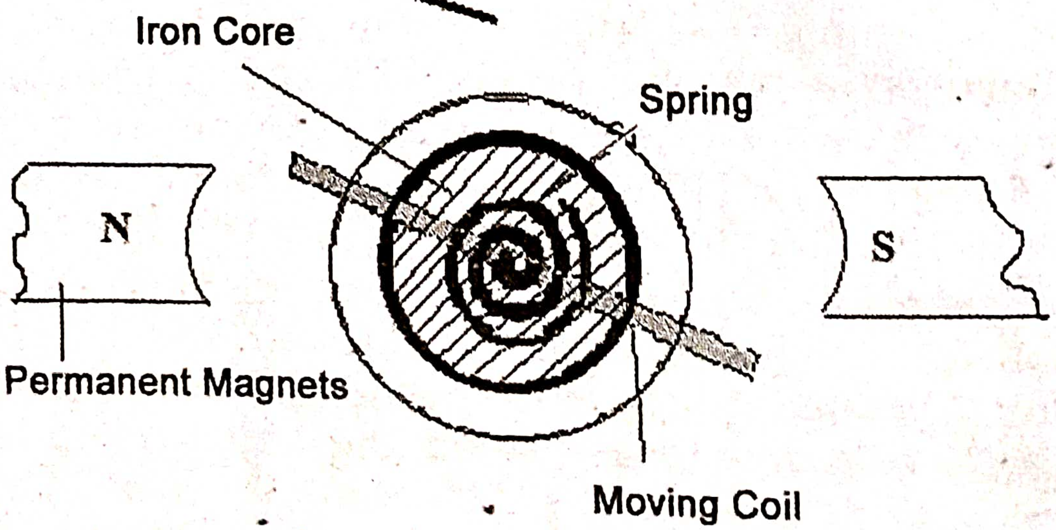
Construction of Moving Coil Galvanometer :

The moving coil galvanometer is made up of a rectangular coil that has many turns and it is usually made of thinly insulated or fine copper wire that is wounded on a metallic frame. The coil is free to rotate about a fixed axis. A phosphor-bronze strip that is connected to a movable torsion head is used to suspend the coil in a uniform radial magnetic field.

Essential properties of the material used for suspension of the coil are conductivity and a low value of the torsional constant. A cylindrical soft iron core is symmetrically positioned inside the coil to improve the strength of the magnetic field and to make the field radial. The lower part of the coil is attached to a phosphor-bronze spring having a small number of turns. The other end of the spring is connected to binding screws.

The spring is used to produce a counter torque which balances the magnetic torque and hence help in producing a steady angular deflection. A plane mirror which is attached to the suspension wire, along with a lamp and scale arrangement is used to measure the deflection of the coil. Zero-point of the scale is at the centre.

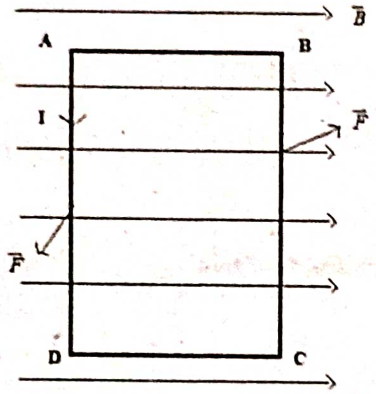


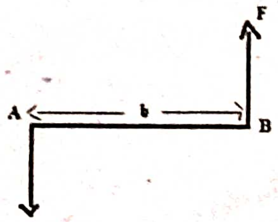


Working of Moving Coil Galvanometer :

Let a current I flow through the rectangular coil of n number of turns and a cross-sectional area A. When this coil is placed in a uniform radial magnetic field B, the coil experiences a torque τ.

Let us first consider a single turn ABCD of the rectangular coil having a length l and breadth b. This is suspended in a magnetic field of strength B such that the plane of the coil is parallel to the magnetic field. Since the sides AB and DC are parallel to the direction of the magnetic field, they do not experience any effective force due to the magnetic field. The sides AD and BC being perpendicular to the direction of field experience an effective force F given by F = Bil.





Using Fleming's left-hand rule we can determine that the forces on AD and BC are in opposite direction to each other. When equal and opposite forces F called couple acts on the coil, it produces a torque. This torque causes the coil to deflect.

We know that torque τ

= force $\times$ perpendicular distance between the forces

$\tau = F \times b$

Substituting the value of F we already know,

Torque τ acting on single-loop ABCD of the coil = $Bil \times b$

Where $l \times b$ is the area A of the coil,

Hence the torque acting on n turns of the coil is given by $\tau = niAB$

The magnetic torque thus produced causes the coil to rotate, and the phosphor bronze strip twists. In turn, the spring S attached to the coil produces a counter torque or restoring torque $k\theta$ which results in a steady angular deflection.

Under equilibrium condition :

$$k\theta = nIAB$$

Here k is called the torsional constant of the spring (restoring couple per unit twist). The deflection or twist θ is measured as the value indicated on a scale by a pointer which is connected to the suspension wire.

$$\theta = (nAB/k)I$$

Therefore $\theta \propto I$

The quantity nAB/k is a constant for a given galvanometer. Hence it is understood that the deflection that occurs the galvanometer is directly proportional to the current that flows through it.

Sensitivity of Moving Coil Galvanometer :

The general definition of the sensitivity experienced by a moving coil galvanometer is given as the ratio of change in deflection of the galvanometer to the change in current in the coil.

$$S = d\theta/dI$$

The sensitivity of a galvanometer is higher if the instrument shows larger deflection for a small value of current. Sensitivity is of two types, namely current sensitivity and voltage sensitivity.

Current Sensitivity :

The deflection θ per unit current I is known as current sensitivity θ/I

$$\theta/I = nAB/k$$

Voltage Sensitivity :

The deflection θ per unit voltage is known as Voltage sensitivity θ/V. Dividing both sides by V in the equation $\theta = (nAB / k)I$;

$$\theta/V = (nAB / V k)I = (nAB / k)(I/V) = (nAB / k)(1/R)$$

R stands for the effective resistance in the circuit.

It is worth noting that voltage sensitivity = Current sensitivity/ Resistance of the coil. Therefore under the condition that R remains constant; voltage sensitivity $\propto$ Current sensitivity.

Merit of a Galvanometer :

It is the ratio of the full-scale deflection current and the number of graduations on the scale of the instrument. It also the reciprocal of the current sensitivity of a galvanometer.

Factors Affecting Sensitivity of a Galvanometer

(a) Number of turns in the coil

(b) Area of the coil

(c) Magnetic field strength B

(d) The magnitude of couple per unit twist k/nAB

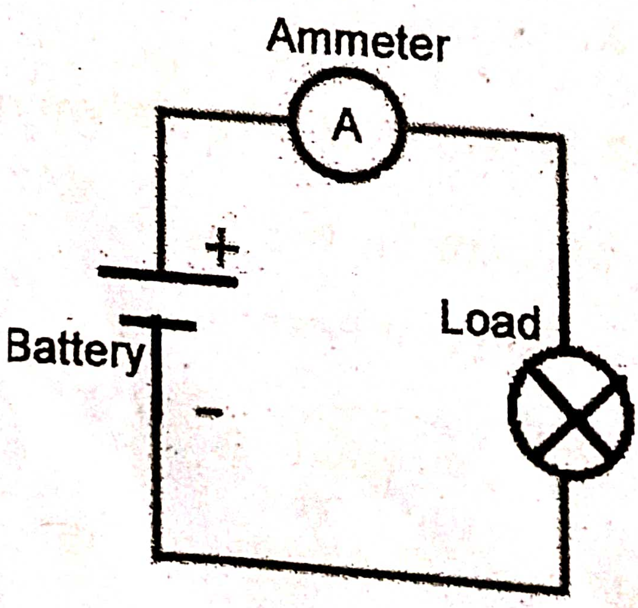
Q. 6. Explain working and construction of Ammeter.

A device or instrument that is used to measure the current is called the ammeter. The unit of the current is ampere. So this device measures the current flow in ampere is named as an ammeter or ampere meter. The internal resistance of this device is '0' however in practical it has some amount of internal resistance. The measuring range of this device mainly depends on the resistance value.

The working principle of an ammeter mainly depends on resistance as well as inductive reactance. This device includes extremely less impedance because it must include less amount of voltage drop across it. It is connected in series because the flow of current within the series circuit is the same.

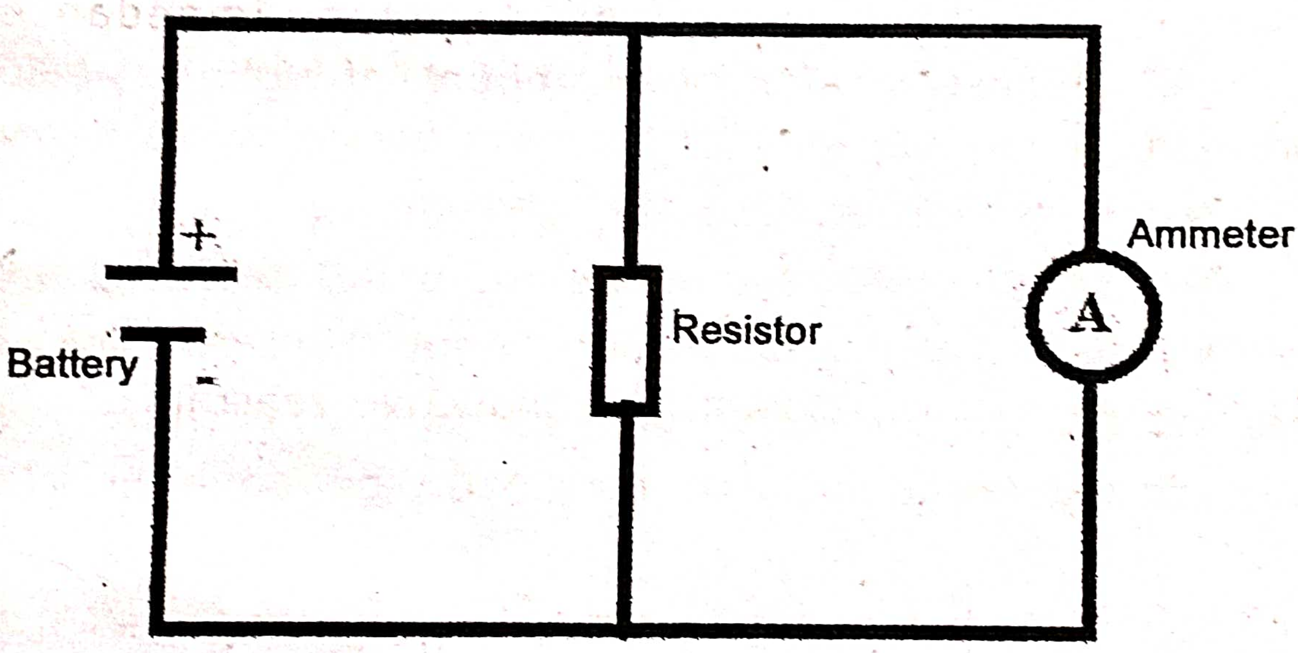
The main function of this device is to measure the flow of current with the help of a set of coils. These coils have very low resistance & inductive reactance.

The construction of ammeter can be done in two ways like series and shunt. The following circuit represents the basic circuit diagram and the connection of the ammeter circuit in series and parallel are shown below.



Once this device is connected in series in the circuit, then the total measure and current will flow through the meter. So the loss of power occurs within ammeter due to their internal resistance. This circuit includes less resistance so less voltage drop will occur within the circuit.

Here, the resistance of this device is kept small due to the reasons like the total measure and current will flow throughout the ammeter and less voltage drop will occur across the device.



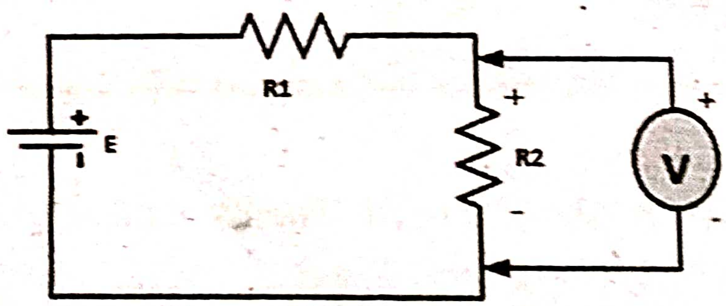
When the high current flows through this device, the internal circuit of the device will be damaged. To overcome this problem in the circuit, the shunt resistance can be connected within parallel to the ammeter. If the huge measure and current supplies throughout the circuit, the main current will pass throughout the shunt resistance. This resistance will not have an effect on the function of a device.

Q. 7. Explain working and construction of Voltmeter.

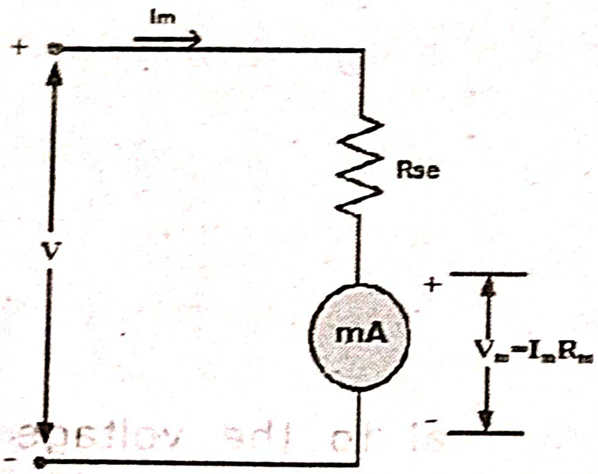
A Voltmeter is a measuring instrument which measures the voltage between two nodes in an electric circuit. In analog voltmeters the pointer moves across a scale in proportional to the voltage of the circuit. Digital voltmeters have a numerical display of voltage by using an analog to digital converter.

Working and Principle of Voltmeter :

Its Working is based on the principle of Ohm's law. Ohm's law states that "Voltage across a resistance is directly proportional to the current passing through it". Any basic meter has a potential difference across its terminals when a full-scale current flows through it. The symbol to represent the voltmeter is a circle with an enclosed letter V.



A voltmeter is always connected in parallel to the component in a circuit for which the voltage is to be measured. A DC volt-meter has polarity signs on it. Therefore one has to connect the plus (+) terminal of the volt-meter to the higher point of potential and the minus (-) terminal to the lower point of potential in order to obtain a meter deflection.



In an AC volt-meter there is no polarity signs on it and can be connected anyways. However, in this case also, the voltmeter is still connected in parallel to the component for which the voltage is measured.

Voltage Equation :

The resistance in series is called a multiplier. Its value is determined from the Voltage Equation.

$$V = I_m R_{sc} + V_m$$

Where,

V = Voltage,

I_m = Full scale current,

R_{se} = Resistance in Series, and

V_m = Full Scale Voltage

Voltage Sensitivity : Voltage Sensitivity is the reciprocal of the current necessary for full scale deflection.

$$\text{Voltage sensitivity} = \frac{1}{I}\ \Omega/\text{Volt.}$$

The smaller the meter current, the larger the voltage sensitivity will be. The actual voltmeter resistance equals the sensitivity times the complete voltage. The voltmeter resistance will always be constant even though the voltage reading may not be a full-scale reading.

Q. 8. *Explain about multimeter and how can we measure different parameters with multi-meter.*

Multimeters an instrument designed to measure electric current, voltage, and usually resistance, typically over several ranges of value.

Uses of Multimeter :

Multimeters can be used as an ammeter, a voltmeter, an ohmmeter by operating a multi-position knob on the meter. They can measure DC as well as AC. There are also special functions in a multimeter like 'Detecting a Short Circuit', testing transistors and some have additional features for measuring capacitance & frequency.

They are two types of multimeters available in market :

(a) Analog Multimeter : (1) Analogue meters take a little power from the circuit under test to operate their pointer. (2) They must have a high sensitivity of at least 20k/V or they may upset the circuit under test and give an incorrect reading.

(b) Digital Multimeter : (1) All digital meters contain a battery to power the display so they use virtually no power from the circuit under test. (2) They have a digital display.

There DC voltage ranges have a very high resistance of 1M or more, usually 10 M, and they are very unlikely to affect the circuit under test.

Working of digital multimeter :

There are three sockets of wire, the black lead is always connected into the socket marked COM, short form for COMMON. The red lead is connected into the socket labeled V mA. The 10A socket is very rarely used..

Measuring resistance with a multimeter :

(1) Set the meter to a resistance range greater than you expect the resistance to be.

(2) Touch the meter probes together and check that the meter reads zero.

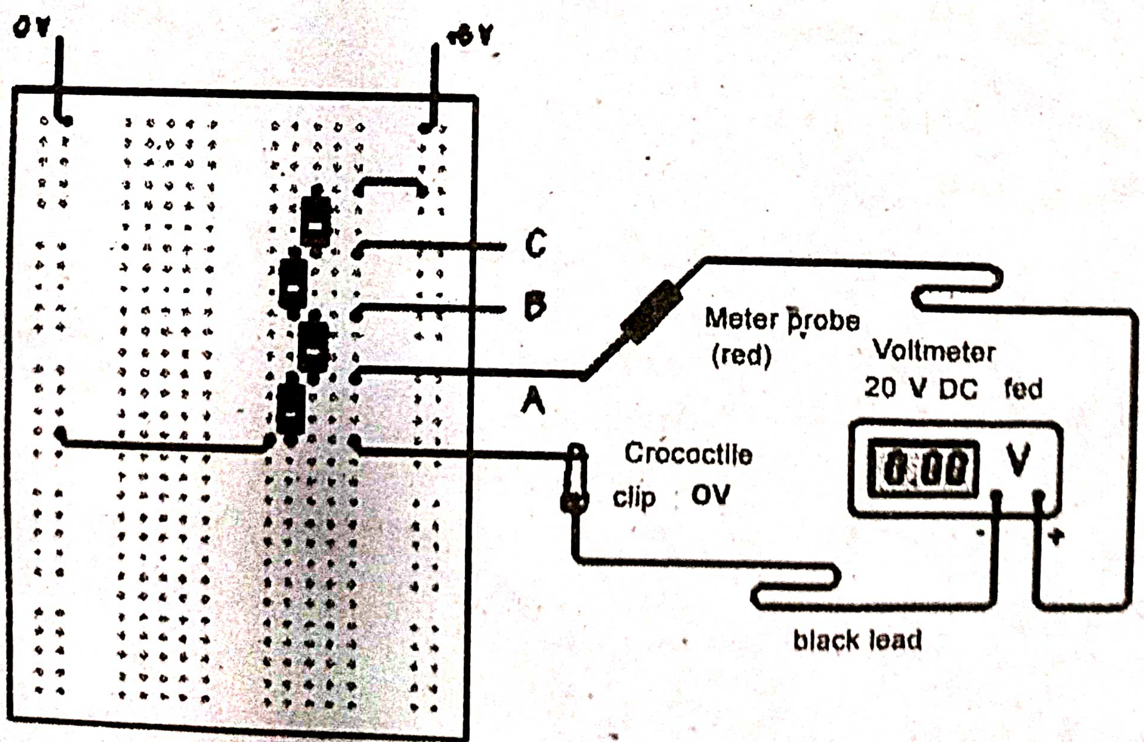
(3) Put the probes across the component.

Measuring Voltage with Voltmeter :

(1) Select a voltage range with a maximum greater than you expect the reading to be. If the reading goes off the scale immediately disconnect and select a higher range.

(2) Connect the red (positive +) lead to the point you where you need to measure the voltage

(3) The black lead can be left permanently connected to 0 V while you use the red lead as a probe to measure voltages at various points.



Similarly you can measure the current by choosing a suitable range. If it displays a '1' at left, choose a higher current range.

Testing a diode with a DIGITAL multimeter :

(a) Digital multimeters have a special setting for testing a diode, usually labeled with the diode symbol.

(b) Connect the red (+) lead to the anode and the black (-) to the cathode. The diode should conduct and the meter will display a value.

(c) Reverse the connections. The diode should NOT conduct this way so the meter will display "off the scale" .

Testing a transistor with a multimeter :

Set a digital multimeter to diode test and an analogue multimeter to a low resistance range such as $\times$ 10 ohm as described above for testing a diode.

Test each pair of leads both ways :

(1) The base-emitter (BE) junction should behave like a diode and conduct one way only.

(2) The base-collector (BC) junction should behave like a diode and conduct one way only.

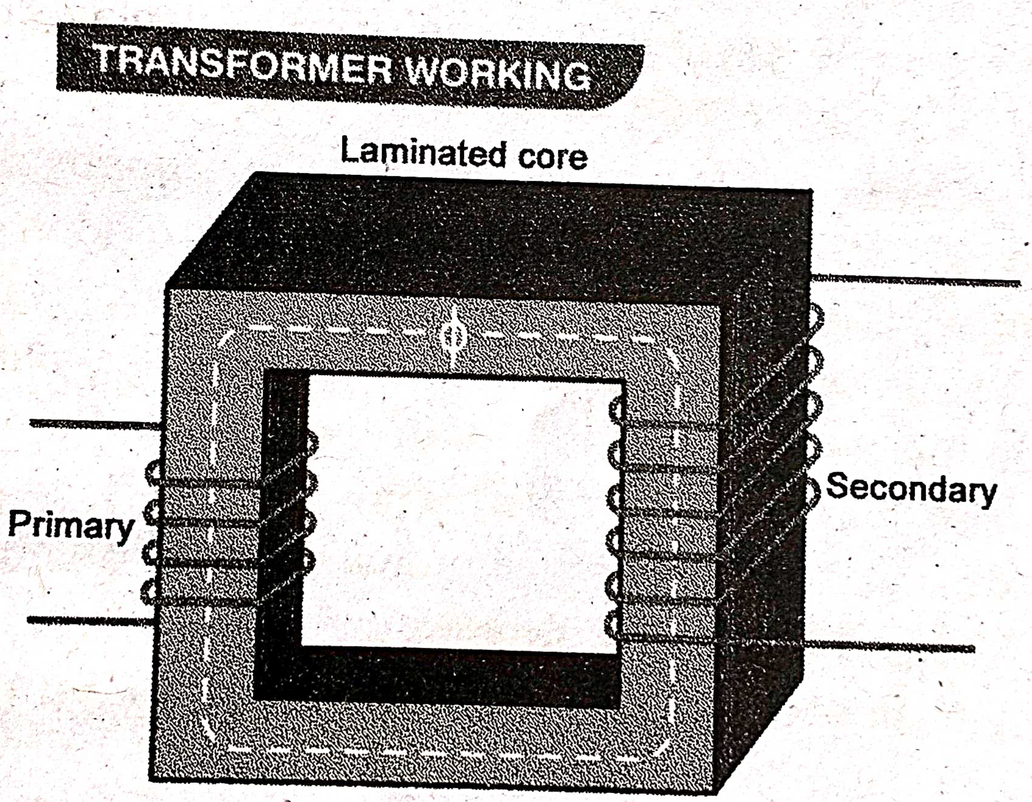
(3) The collector-emitter (CE) should not conduct either way.

Conducting in one way simply means it will behave as a short circuit and The diagram shows how the junctions behave in an NPN transistor. The diodes are reversed in a PNP transistor but the same test procedure can be used. Some multimeters have a 'transistor test' function.

Q. 9. What is Transformer? Explain working of a 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.

Working Principle of a 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, forms a varying magnetic flux as per Faraday's law of electromagnetic induction and 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 :

1. Transfer of electrical energy from circuit to another
2. Transfer of electrical power through electro-magnetic induction
3. Electric power transfer without any change in frequency
4. Two circuits are linked with mutual induction.

Parts of a Single-phase Transformer : The major parts of a single-phase transformer consist of

1. Core : The core acts as a support to the winding in the transformer. It also provides a low reluctance path to the flow of magnetic flux. The winding is wound on the core as shown in the picture. It is made up of a laminated soft iron core in order to reduce the losses in a transformer. The factors such as operating voltage, current, power etc decide core composition. The core diameter is directly proportional to copper losses and inversely proportional to iron losses.

2. Windings : Windings are the set of copper wires wound over the transformer core. Copper wires are used due to

1. High conductivity of copper. This minimizes the loss in a transformer. Since conductivity increases, resistance to current flow decreases.
2. High ductility of copper. Ductility is the property of metals that they can be made into very thin wires.

There are mainly two types of windings Primary windings and secondary windings.

Primary winding : The set of turns of windings to which supply current is feed.

Secondary winding : The set of turns of winding from which output is taken.

The primary and secondary windings are insulated from each other using insulation coating agents.

3. Insulation Agents : Insulation is necessary for transformers to separate windings from shorting the circuit and thus facilitating the mutual induction. Insulation agents have influence in durability and the stability of a transformer.

Following are used as an insulation medium in a transformer

(a) Insulating oil
(b) Insulating tape
(c) Insulating paper
(d) Wood-based lamination.

Q. 10. What is Electrical energy how it works ?

Electrical energy is energy derived from electric potential energy or kinetic energy. When used loosely, electrical energy refers to energy that has been converted from electric potential energy. This energy is supplied by the combination of electric current and electric potential that is delivered by an electrical circuit. At the point that this electric potential energy has been converted to another type of energy, it ceases to be electric potential energy. Thus, all electrical energy is potential energy before it is delivered to the end-use. Once converted from potential energy, electrical energy can always be called another type of energy (heat, light, motion, etc.).

Electrical energy is usually sold by the kilowatt hour (1 kW·h = 3.6 MJ) which is the product of the power in kilowatts multiplied by running time in hours. Electric utilities measure energy using an electricity meter, which keeps a running total of the electric energy delivered to a customer.

Electrical energy is a form of energy resulting from the flow of electric charge. Energy is the ability to do work or apply force to move an object. In the case of electrical energy, the force is electrical attraction or repulsion between charged particles. Electrical energy may be either potential energy or kinetic energy, but it's usually encountered as potential energy, which is energy stored due to the relative positions of charged particles or electric fields. The movement of charged particles through a wire or other medium is called current or electricity. There is also static electricity, which results from an imbalance or separation of the positive and negative charges on an object. Static electricity is a form of electrical potential energy. If sufficient charge builds up, the electrical energy may be discharged to form a spark (or even lightning), which has electrical kinetic energy. By convention, the direction of an electric field is always shown pointing in the direction a positive particle would move if it was placed in the field. This is important to remember when working with electrical energy because the most common current carrier is an electron, which moves in the opposite direction compared with a proton.

SHORT ANSWER QUESTIONS

Q. 1. Define voltage and give units for voltage.

Voltage is the pressure from an electrical circuit's power source that pushes through a conducting loop Voltage is caused by potential difference between two points.

Voltage is defined as the work needed per unit charge to move a test charge between the two points.

Voltage is also defined so that negatively charged objects are pulled towards higher voltages, while positively charged objects are pulled towards lower voltages. Therefore, the conventional current in a wire or resistor always flows from higher voltage to lower voltage.

Units for voltage in SI system are volts.

Volt is defined as the difference in electric potential between two points of a conducting wire when an electric current of one ampere dissipates one watt of power between those points.

V = potential/charge = J/C = Kg.met^2/A.s^3.

Q. 2. Define Electric current and give units for Electric current.

Electric Current is the flow of electrical charge carriers like electrons. Current flows from negative to positive points.

An electric current is the rate of flow of electric charge past a point or region. An electric current is said to exist when there is a net flow of electric charge through a region. Electric charge is carried by charged particles, so an electric current is a flow of charged particles

Electric current is measured using a device called an ammeter.

The SI unit of current is ampere which measures the flow of *electric charge across a surface at the rate of one coulomb per second.* Since the charge is measured in coulombs and time in seconds, so the unit is **coulomb/Sec** (C/s) or **amp**.

Q. 3. *What is Resistance and give units for Resistance.*

Resistance is an electrical quantity that measures how the device or material reduces the electric current flow through it.

Resistance is the hindrance to the flow of electrons in material. While a potential difference across the conductor encourages the flow of electrons, resistance discourages it.

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses.

Units of resistance is ohm : Ohm defines the unit of resistance of "1 Ohm" as the resistance between two points in a conductor where the application of 1 volt will push 1 ampere, or 6.241×10^{18} electrons.

Q. 4. Derive ohm's law and give applications and limitations of ohm's law.

Ohm's Law states that the current flowing through a conductor is directly proportional to the potential difference applied across its ends, provided the temperature and other physical conditions remain unchanged. Mathematically it can be represented as

$$\text{Potential difference} \propto \text{Current}$$

$$V \propto I$$

$$V = IR$$

Where,

V is Voltage in volts (V)

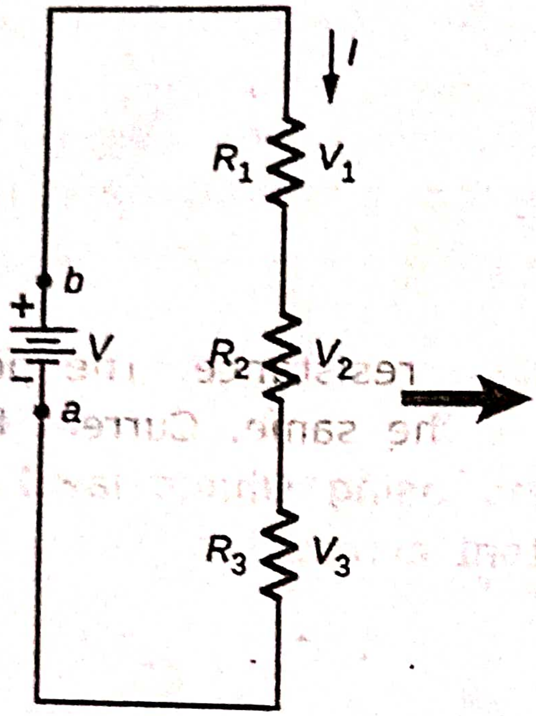
R is Resistance in ohm (Ω)

I is Current in Ampere (A).

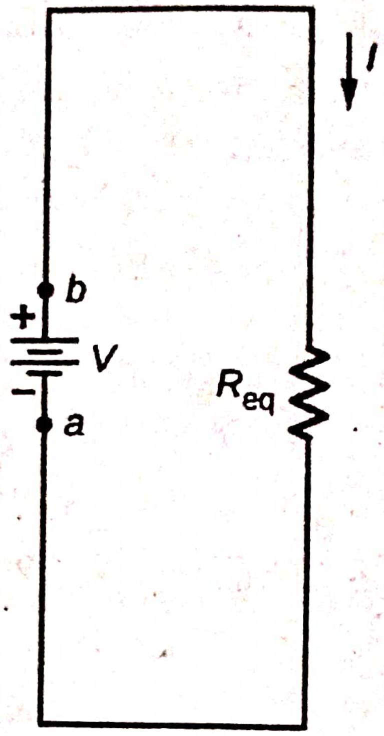
Q. 5. Derive formula for Resistors are connected in series.

Resistors are said to be in series whenever the current flows through the resistors sequentially.

Consider three resistors in series with an applied voltage. There is only one path for the charges to flow through the current is the same through each resistor. The equivalent resistance of a set of resistors in a series connection is equal to the algebraic sum of the individual resistances.



(a) Original circuit



(b) Equivalent circuit

The current through the circuit depends on the voltage supplied by the voltage source and the resistance of the resistors. For each resistor, a potential drop occurs that is equal to the loss of electric potential energy as a current travels through each resistor. According to Ohm's law, the potential drop across a resistor when a current flows through it is calculated using the equation V = IR, where I is the current in amps and R is the resistance in ohms. Since energy is conserved, and the voltage is equal to the potential energy per charge, the sum of the voltage applied to the circuit by the source and the potential drops across the individual resistors around a loop should be equal to zero The sum of the potential drop of each resistor and the voltage supplied by the voltage source should equal zero.

$$V - V_1 - V_2 - V_3 = 0$$

$$V = V_1 + V_2 + V_3$$

$$V = IR_1 + IR_2 + IR_3$$

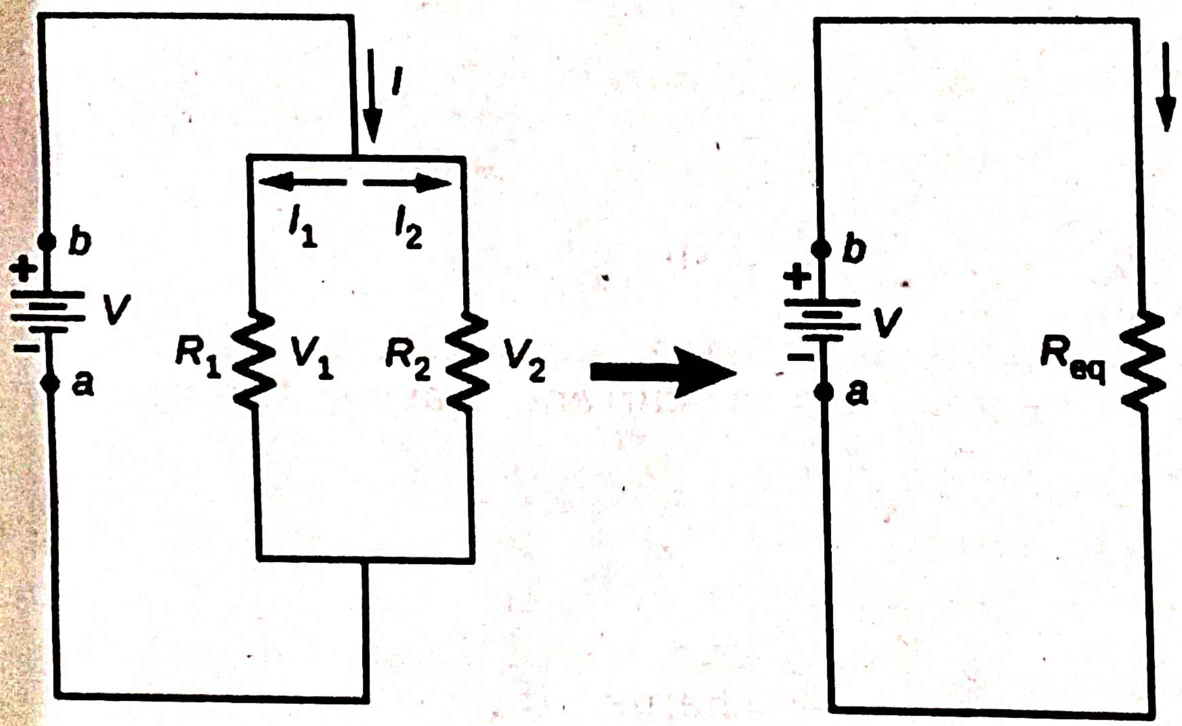
$$IR = IR_1 + IR_2 + IR_3$$

$$R = R_1 + R_2 + R_3$$

If circuit consists of n number of resisters resultant resistance is $R = R_1 + R_2 + R_3 + \ldots\ldots R_n$.

Q. 6. Derive formula for Resistors are connected in parallel.

Resistors are in parallel when one end of all the resistors are connected by a continuous wire of negligible resistance and the other end of all the resistors are also connected to one another through a continuous wire of negligible resistance. The potential drop across each resistor is the same. Current through each resistor can be found using Ohm's law $I = V/R$ where the voltage is constant across each resistor.



(a) Original circuit

(b) Equivalent circuit

The current flowing from the voltage source depends on the voltage supplied by the voltage source and the equivalent resistance of the circuit. In this case, the current flows from the voltage source and enter a junction, or node, where the circuit splits flowing through resistors R_1 R_2 and R_3 As the charges flow from the battery. The sum of the currents flowing into a junction must be equal to the sum of the currents flowing out of the junction.

According to Kirchhoff's junction rule $I = I_1 + I_2$

But from ohm's law $I = V/R$

$$V/R = V/R_1 + V/R_2$$

$$V/R = V\,(1/R_1 + I/R_2)$$

$$1/R = (1/R_1 + I/R_2)$$

If circuit consists of n resisters in parallel $1/R = (1/R_1 + I/R_2 + I/R_3 + \text{------} I/R_n)$

Q. 7. What are the applications of Galvanometer ?

Applications of Galvanometer :

The moving coil galvanometer is a highly sensitive instrument due to which it can be used to detect the presence of current in any given circuit. If a galvanometer is a connected in a Wheatstone's bridge circuit, pointer in the galvanometer shows null deflection, i.e no current flows through the device. The pointer deflects to the left or right depending on the direction of the current.

The galvanometer can be used to measure :

(a) the value of current in the circuit by connecting it in parallel to low resistance.

(b) the voltage by connecting it in series with high resistance.

Q. 8. What are the Types of Ammeters.

These are classified into different types based on their applications which include the following. (a) Moving Coil, (b) Electrodynamic, (c) Moving-iron, (d) Hot wire, (e) Digital ammeter, (f) Integrating.

(a) Moving Coil : This type of ammeter is used to measure both AC & DC. This device uses magnetic deflection where the flow of current through a coil will make to move within the magnetic field. The coil in this device moves freely moves between permanent magnet poles.

(b) Electrodynamic : This type of ammeter includes a moving coil to rotate in the generated field through a fixed coil. The main function of this device is to measure AC & DC with an accuracy of 0.1 to 0.25%. The accuracy of this device is high when compared with the moving coil & permanent magnet moving coil. The device calibration is the same for AC & DC.

(c) Moving-iron : This type of ammeter is used to calculate alternating currents & voltages. In this device, the movable system includes specially created soft iron pieces, which move as acted upon through the electromagnetic force of a fixed coil of wire. These types of devices are classified into two types like repulsion and attraction. This device includes different components like moving element, coil, control, damping & reflective torque.

(d) Hot Wire : This is used to measure AC or DC by transmitting it through a wire to make the wire heated and expand is known as a hot wire. The working principle of this device is to increase the wire by providing heat effect from the current supply through it. This is used for both AC & DC.

(e) Digital Ammeter : This type of device is used to measure the flow of current in amperes & displays the values of on a digital display. The designing of this device can be done by using a shunt resistor to generate a calibrated voltage that is proportional to the flow of current. These instruments provide information regarding the current draw & continuity in order to assist the consumer to troubleshoot variable loads & trends.

(f) Integrating : In this device, the flow of current is summed over time and gives the product of time & current. These devices calculate the whole energy supplied through the circuit in a specified interval of time. The best example of this integrating device is watt-hour meter as it measures the energy directly in watt-hour.

Q. 9. *What are the Applications of Ammeter.*

(a) The applications of this device will range from the schools to industries.

(b) These are used to measure the current flow in the buildings to ensure that the flow is not too low or too high.

(c) It is used in manufacturing and instrumentation companies to check the functionality of the devices

(d) It is used with a thermocouple to check the temperature.

(e) Electricians frequently use these devices to check the faults of the circuits in the building.

Q. 10. *Classification of Voltmeters ?*

According to the construction principle, we have different types of voltmeters, they are mainly :

(1) Permanent Magnet Moving coil (PMMC) Voltmeter.

(2) Moving Iron (MI) Voltmeter.

(3) Electro Dynamometer Type Voltmeter.

(4) Rectifier Type Voltmeter.

(5) Induction Type Voltmeter.

(6) Electrostatic Type Voltmeter.

(7) Digital Voltmeter (DVM).

Depending on these types of measurement we do, we have :

(a) DC Voltmeter. (b) AC Voltmeter.

Q. 11. *What are the Types of Transformers.*

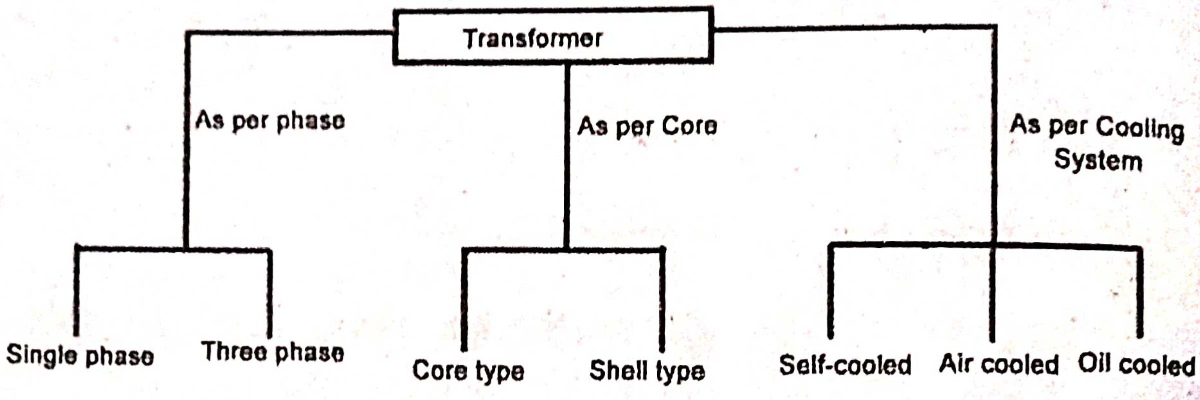
Transformers are used in various fields like power generation grid, distribution sector, transmission and electric energy consumption. There are various types of transformers which are classified based on the following factors.

(a) Working voltage range.

(b) The medium used in the core.

(c) Winding arrangement.

(d) Installation location.



Based on Voltage Levels : Commonly used transformer type, depending upon voltage they are classified as :

(a) Step-up Transformer : They are used between the power generator and the power grid. The secondary output voltage is higher than the input voltage.

(b) Step down Transformer : These transformers are used to convert high voltage primary supply to low voltage secondary output.

Based on the Medium of Core Used : In a transformer, we will find different types of cores that are used.

(a) Air core Transformer : The flux linkage between primary and secondary winding is through the air. The coil or windings wound on the non-magnetic strip.

(b) Iron core Transformer : Windings are wound on multiple iron plates stacked together, which provides a perfect linkage path to generate flux.

Based on the Winding Arrangement : Autotransformer : It will have only one winding wound over a laminated core. The primary and secondary share the same coil. Auto also means "self" in language Greek.

Based on Install Location :

(a) Power Transformer : It is used at power generation stations as they are suitable for high voltage application.

(b) Distribution Transformer : Mostly used at distribution lanes in domestic purposes. They are designed for carrying low voltages. It is very easy to install and characterized by low magnetic losses.

(c) Measurement Transformers : These are further classified. They are mainly used for measuring voltage, current, power.

(d) Protection Transformers : They are used for component protection purposes. In circuits some components must be protected from voltage fluctuation etc. protection transformers ensure component protection.

Q. 12. Define Electric Power.

The rate at which the work is being done in an electrical circuit is called an electric power. In other words, the electric power is defined as the rate of the transferred of energy. The electric power is produced by the generator and can also be supplied by the electrical batteries. It gives a low entropy form of energy which is carried over long distance and also it is converted into various other forms of energy like motion, heat energy, etc.

The electric power is divided into two types, i.e., the AC power and the DC power. The classification of the electric power depends on the nature of the current. The electric power is sold regarding joule which is the product of the power in kilowatts and the running time of the machinery in hours. The utility of power is measured by the electric meter which records the total energy consumed by the powered devices.

$$\text{Electrical Power} = \frac{\text{Work done in an electrical current}}{\text{time}}$$

$$P = \frac{VIt}{t} = VI = I^2R = \frac{V^2}{R}$$

Where V is the voltage in volts, I is the current in amperes, R is the resistance offered by the powered devices, T is the time in seconds and the P is the power measured in watts.

Unit of Electric Power :

The unit of electrical power is Watt.

$V = 1$ voltsand $I = 1$ ampere

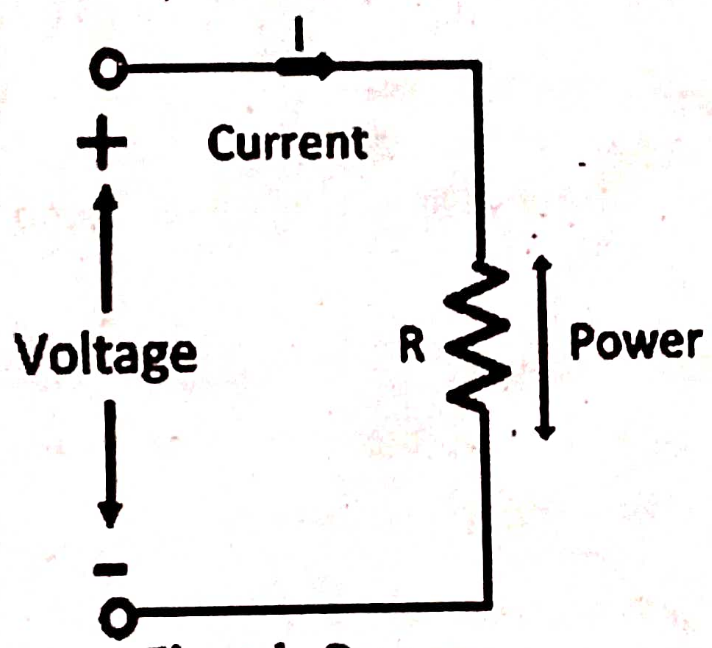
$P = 1$ watt

Thus, the power consumed in an electrical circuit is said to one watt if one ampere current flows through the circuit when a potential difference of 1 volt is applied across it. The bigger unit of electrical power is the kilowatt (kW), it is usually used in the power system.

Q. 13. Explain about Types of an Electric Power.

The electrical power is mainly classified into two types. They are the DC power and the AC power.

1. DC Power : The DC power is defined as the product of the voltage and current. It is produced by the fuel cell, battery and generator.



Electric Power

$$P = V \times I$$

Where P = Power in watt.

V = Voltage in volts.

I = Current in amps.

2. AC Power : The AC power is mainly classified into three types. They are the apparent power, active power and real power.

1. Apparent Power : The apparent power is the useless power or idle power. It is represented by the symbol S, and their SI unit is volt-amp.

$$S = V_{rms} I_{rms}$$

Where S = apparent power

V_{rms} = RMS voltage = $V_{peak}\sqrt{2}$ in volt.

I_{rms} = RMS current = $I_{peak}\sqrt{2}$ in the amp.

2. Active Power : The active power (P) is the real power which is dissipated in the circuit resistance.

$$P = V_{max} I_{max} \text{ Cos } \phi$$

Where, P = The real power in watts.

V_{max} = RMS voltage = $V_{peak}\sqrt{2}$ in volts.

I_{max} = RMS current = $I_{peak}\sqrt{2}$ in the amp.

ϕ = Impedance phase angle between voltage and current.

3. Reactive Power : The power developed in the circuit reactance is called reactive power (Q). It is measured in volt-ampere reactive.

$$Q = V_{rms} I_{rms} \text{ Sin } \phi$$

Where, Q = The reactive power in watts.

V_{rms} = RMS voltage = $V_{peak}\sqrt{2}$ in volt.

I_{rms} = RMS current = $I_{peak}\sqrt{2}$ in the amp.

ϕ = Impedance phase angle between voltage and current.

The relation between the apparent, active and reactive power is shown below.

$$S^2 = Q^2 + P^2$$

The ratio of the real to the apparent power is called power factor, and their value lies between 0 and 1.

Q. 14. Define kilowatt-hour (kWh) and explain consumption of electric power.

The kilowatt-hour (kWh) is a unit of energy equivalent to one kilowatt (1kW) of power expended for one hour (1 h) of time. The kilowatt-hour is not a standard unit in any formal system, but it is commonly used in electrical applications.

An energy expenditure of 1 kWh represents 3,600,000 joules (3.600×10^6 J). To obtain joules when kilowatt-hours are known, multiply by 3.600×10^6. To obtain kilowatt-hours when joules are known, multiply by 2.778×10^{-7}.

In general, energy (E) is equivalent to power (P) multiplied by time (t). To determine E in kilowatt-hours, P must be expressed in kilowatts and t must be expressed in hours.

The consumption of electrical energy or Electrical power :

The consumption of electrical energy by homes and small businesses is usually measured in kilowatt-hours. Larger businesses and institutions sometimes use the megawatt-hour (MWh), where 1 MWh = 1,000 kWh. The energy outputs of large power plants over long periods of time, or the energy consumption of states or nations, can be expressed in gigawatt hours (GWh), where 1 GWh = 1,000 MWh = 10^6 kWh.