**CURRENT ELECTRICITY**

**ELECTRIC CURRENT**

**DEFINITION: -**

The net charge which passes through any cross-section of a conductor in a particular direction is called electric current.

**OR**

It is the rate of flow of charge in a particular direction.

**MATHEMATICAL EXPRESSION: -**

If the amount of charge is flowing through the conductor in a time in a specified direction then the electric current is given as:

**UNIT: -**

The S.I unit of current is Ampere which can be defined as, “If a charge of one coulomb is flowing through the conductor in a time of one second then the amount of current established in it is one ampere.”

**OR**

is the current flowing in each of the two infinite parallel wires of negligible cross section when they are apart in vacuum and exert a force of on each other.

**CONDUCTORS: -**

Substances which allow electricity to flow through them are called conductors.

In these substances valence electrons (outer most electron) are loosely attached to their atoms. These electrons move freely in the interatomic spaces and therefore known as free electrons. These free electrons are responsible for the conduction of electricity through conductors.

**EXAMPLES: -**

Silver is the best of the metallic conductors, copper is the next best and all metals are good conductors.

**FREE ELECTRONS: -**

The electrons of outermost orbit in an atom are termed as free electrons. These electrons move freely in the interatomic spaces and are responsible for the conduction of electricity through conductors.

**BOUND ELECTRON: -**

The electron in the innermost orbit of an atom is called bound electron which is attached to a particular atom and does not move atom to atom in a substance.

**INSULATORS: -**

Substances which do not allow electricity to flow through them are called insulators. These are the substance in which valence electrons (outermost electron) are rigidly held by their atoms. They do not contain free electrons and for the same reason they cannot electricity.

**DRIFT VELOCITY:**

1. At normal condition i.e. when there is no battery connected across a conductor, the free electrons move in random directions and the number of electrons moving in one direction is just equal to the number of electron moving in opposite direction. Thus the net current in the conductor is zero.
2. If the ends of a conductor are connected to a battery an electric field will be setup at every point with in the conductor. The free electrons in the conductor will move in a direction opposite to that of the E and will acquire a drift velocity.
3. The velocity attained by the electrons due to applied electric field is called drift velocity and their rate of flow is called drift current.

The typical value of drift velocity is .

**ELECTRONIC CURRENT**

**DEFINITION: -**

It is the current due to flow of charges (electrons) and it is always flow from lower potential (negative terminal of the battery) to higher potential (positive terminal of the battery).

**CONVENTIONAL CURRENT: -**

1. It is the current due to the flow of charges and it flows from higher potential to lower potential.
2. Although in most of the conductors current is due to the flow of electrons but often it is con to think in terms of flow of positive charges as it simplifies calculation.
3. Electronic current in a given direction is equivalent to the conventional current of the same magnitude in the opposite direction.

**IMPORTANT POINT TO REMEMBER:**

Experiments on magnetic effect of an electric current shows that effects of an electronic current due to flow of negative charges is same as that of a current due to equal amount of positive charges.

**OHM’S LAW**

**STATEMENT: -**

The current through a conductor is directly proportional to the potential difference between the ends of the conductors, provided that physical conditions remain the same.

**MATHEMATICAL EXPRESSION: -**

If the current established in the conductor is and the potential difference applied across its end is then according to Ohm’s Law:

Where is a constant of proportionality and is called as conductance of a material.

Since the reciprocal of conductance is termed as the resistance of the conductor. i.e.

Where is resistance of the material.

**LIMITATIONS OF OHM’S LAW**

1. All the metals obey ohm’s law provided physical conditions remain unchanged.
2. Semiconductors and their devices do not obey Ohm’s law. For examples Silicon and diode etc. also conduction of electricity through gases do not obey ohm’s law.

**GRAPHICAL REPRESENTATION: -**

If a graph is plotted between potential difference and current a straight line is obtained which shows that the current is directly proportional to the potential difference.

**RESISTANCE: -**

**DEFINITION: -**

It is the opposition offered to the motion of free electrons due to the continuous collision with the atoms of the conductor.

**UNIT OF RESISTANCE: -**

S.I unit of resistance is ohm and it is denoted by a Greek symbol (OMEGA).

**OHM**

The resistance of a conductor is said to be one ohm. If current through it is one ampere when potential difference across it is one volt.

i.e.

**CONDUCTANCE: -**

The reciprocal of resistance is defined as conductance and is denoted . i.e.

It is the case offered by a conductor to the flow of current:

Ohm’s law can also be written as,

S.I unit of conductance is which may defined as,

“Conductance of a conductor will be . If a P.D of across its terminals produces steady current through it.”

i.e.

i.e.

**FACTORS EFFECTING RESISTANCE**

The resistance of a conductor depends upon the following factors: -

1. **LENGTH OF THE CONDUCTOR: - ‘L’**

Resistance of a conductor increases by increasing the length of the conductor. i.e.

1. **AREA OF CROSS SECTION: - ‘A’**

The resistance of a conductor decreases by increasing the area of cross section of the conductor. i.e.

1. **NATURE OF CONDUCTOR: -**

Resistance of a conductor also depends upon a nature of material of a conductor. s

By combining eq. (i) and (ii) we get,

**Or**

Where, is a constant of proportionality and is called as “RESISTIVITY” or “SPECIFIC RESISTANT”

If,

And

Then from equation (iii):

**Or**

From equation no (iv) resistivity of a conductor is defined as , “It is the resistance of a conductor whose length is and area of cross section is ”.

**OR**

It can be defined as the resistance offered by the unit length of the wire of unit area of cross-section.

**OR**

Resistivity is the resistance of a meter cube of a conductor.

**S.I UNIT: -**

The S.I unit of resistivity is ohm-meter i.e. .

**CONDUCTIVITY: -**

The reciprocal of resistivity is called as conductivity. i.e.

S.I unit of Conductivity is

**EFFECT OF TEMPERATURE ON RESISTANCE**

1. When an electric current is passes through a cross section of a conductor it offers some resistance which is due to the collision of free electrons with the atoms of the conductor.
2. As the temperature increases the atoms of conductor vibrate with longer amplitude and the probity of collisions of free electrons with the atoms of the conductor increases. This causes decrease in drift velocity of a electrons for a given voltage and the decrease in velocity causes decrease in current or increase in resistivity.
3. Thus we conclude that resistance increases on increasing the temperature.
4. From experiments it has been found that resistance of a conductor varies linearly above and below for a wide range of temperature.
5. Let,

And,

From experiments it has been found that,

By combining eq. (i) and (ii) we get

Where,

And

constant of proportionality and is called as temperature coefficient of resistance and its value depends upon the nature of conductor from equation no. (iii).

The temperature coefficient of resistance is defined as the change in resistance per unit original resistance at per unit rise in temperature.

**OR**

It is the fractional change in resistance for rise in temperature.

It is expressed in .

**TEMPERATURE COEFFICIENT OF RESISTANCE IN TERMS OF RESISTIVITY**

As the resistance of a conductor is directly proportional to resistivity.

may be written as,

Where refer to resistivity’s at respectively.

**COMBINATION OF RESISTORS**

**SERIES COMBINATION**

When resistors are connected in such a way that there is only one path for the flow of current then such type of combination is called as Series Combination.

In series combination same current flows through each resistor.

**CHARACTERISTIC OF SERIES COMBINATION**

**TOTAL RESISTANCE: -**

1. Let are three resistors which are connected in series across a battery of Volt as shown.
2. Since the combination is series so the sum of potential difference across each resistor is equal to the potential difference of the battery. i.e.

Also in series combination same current flows through each resistor therefore,

1. Now by the application of ohm’s law we have,

Substituting the value of in eq. (i)

1. If are replaced by an equivalent resistor then,
2. Substituting the value of in eq. (ii)
3. For resistors connected in series.

**CONCLUSION: -**

From the above equation we conclude that in series combination the equivalent resistance of the circuit is equal to the sum of the individual resistance of each resistor.

Finally we conclude that:

1. The current passing through each resistor connected in series is same i.e.
2. The sum of potential difference across each resistor is equal to the potential difference of the battery i.e.
3. The total resistance of the circuit is equal to the sum of the individual resistance.

**PARALLEL COMBINATION**

The combination of resistors in which more than one path is provided to flow the current is called parallel combination of resistors.

In parallel combination resistors are connected across the same pair of terminals so that all of them have the same potential according to their terminals.

**CHARACTERISTIC OF PARALLEL COMBINATION**

**TOTAL RESISTANCE: -**

1. Consider a parallel combination of three resistors as shown.
2. If current through be respectively then in parallel combination the current of the circuit is equal to the sum of the current through each resistor i.e.
3. Now by the application of Ohm’s law on each resistor we get,

Since potential difference across each resistor is same. i.e.

Similarly,

And,

1. If are replaced by an equivalent resistor then,

For resistance (resistors) in parallel combination.

**CONCLUSION: -**

From the above equation we conclude that the reciprocal of equivalent resistance for a parallel combination is equal to the sum of the reciprocals of all the resistance connected in parallel.

Since reciprocal of resistance is defined as conductance and it is denoted by K. i.e.

may be written as,

From the above equation we conclude that in parallel combination of resistance the sum of the individual conductance is equal to the equivalent conductance in the network.

Finally we conclude that:

1. The reciprocal of total resistance of the circuit is equal to the sum of reciprocal of individual resistance.
2. The potential difference of each resistors is same i.e.
3. The total current of the circuit is equal to the sum of the current flowing through each resistors.

**POWER DISSIPATION IN RESISTORS**

1. When electric current flows through a resistor free electrons collide with the atoms of the resistor thus increasing the vibrational energy of the atoms of the resistor. Hence energy lost by the electron during these collision is gained by the atoms of the resistor in the form of heat.
2. When charge flows through a potential difference . The energy lost by the charge is given as:

This energy appears in the form of heat energy. Hence the heat developed in the resistor in sec is .

1. As we know that energy spent (or work done) per unit time is called power. Therefore power dissipated (power lost) in the resistor is given by,

According to Ohm’s law

Again from Ohm’s law

**UNIT OF POWER: -**

The unit of power is and is called watt and it is derived as:

i.e.

As we know that:

And

**COMMERCIAL UNIT OF ELECTRICAL ENERGY**

The commercial unit f electrical energy is kilowatt hour

One kilowatt hour is the amount of energy delivered by the current in one hour when it supplies energy at the rate of .

i.e.

**HEAT ENERGY**

If a current I flows steadily through a resistor for time . The total heat energy supplied to the resistor is given as:

**OR**

**OR**

**ELECTROMOTIVE FORCE**

When an electric current passes through a resistor connected to Volt battery which is a device for producing electrical energy then electrical energy is continuously dissipated as heat to maintain continuous flow of current the energy must be supplied at the same rate at which it is dissipated the strength of such a source is called electromotive force (e.m.f).

**OR**

The energy given by the source in flowing unit charge in the whole circuit (including the source) is called electromotive force of the source.

**OR**

The potential difference that exist between two terminals of the source of electrical energy when it is not connected to any external circuit is called its electromotive force.

**UNIT: -**

The unit of E.M.F is

**SOURCES OF E.M.F**

In all kinds of sources of E.M.F some kind of energy is transformed into electrical energy. For Examples:

1. Batteries or cells convert chemical energy into electrical energy.
2. Generators convert mechanical energy into electrical energy.
3. Thermocouples convert heat energy into electrical energy.
4. Photocell convert light energy into electrical energy.

**TERMINAL POTENTIAL DIFFERENCE**

It is the voltage (potential difference) appearing across the terminals of a battery when it is supplying current to an external circuit, and it can be defined as the amount of work done in carrying a unit positive charge from one terminal (- ive terminal) to the other (+ ive terminal) against the direction of electric intensity.

**RELATION BETWEEN E.M.F, LOST VOLTAGE & T.P.D (TERMINAL POTENTIAL DIFFERENCE)**

1. When a current flows through a source of electrical energy, it experiences an opposition offered by the source itself. This opposition which is due to presence of electrolyte between the electrodes is known as internal resistance of the source commonly denoted by .
2. Consider a battery of E.M.F and internal resistance connected to an external resistance .

N.B: [A battery of E.M.F and having an internal resistance is equivalent to a source of pure E.M.F with a resistance in series as shown above]

According to Ohm’s Law

Where,

1. is the potential difference across the external resistance and it is also termed as terminal potential difference.

i.e.

i.e. when no current is being drawn from a battery then its terminals potential difference is equal to its E.M.F.

1. is the potential difference across internal resistance and it is termed as “lost voltage”.