Chapter ÷ 2

Electronic Fundamentals

Voltage

→ It is the expression of potential difference between two points within electricfield.
→ It is denoted by 'V'
→ It's unit is volt.

Current

→ An electric current is the rate of flow of electric charge where this charges ~~where~~ are often electrons, ion and plasma (ionized gases).
→ Current is denoted by 'I'. Its unit is Ampere

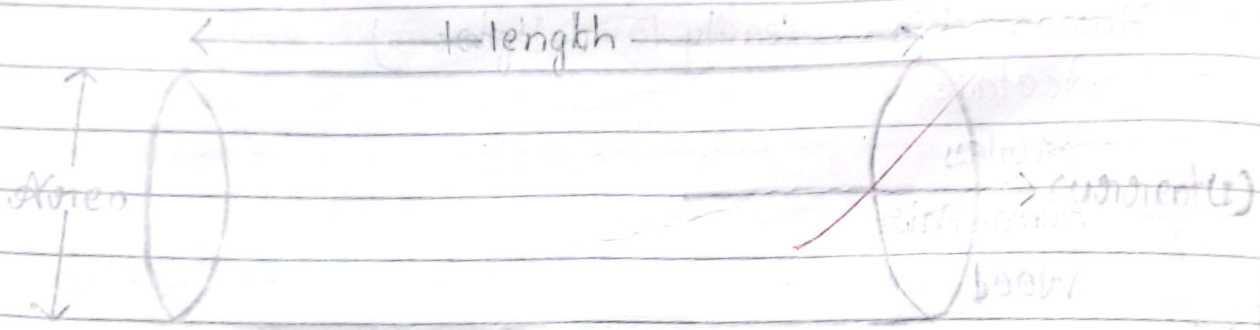


Fig: Conductor

If a small ~~curso~~ cross-section of wire could be isolated and quantity of the charge(q) passing through this cross-section in certain amount of time, then the current is given by:

$$\boxed{I = \frac{q}{t}}$$

Resistance (R)

- It is the property of resistor that gives the measurement of difficulty to pass electric current through it.
- It's SI unit is ohm (Ω).
- It is also defined as the ratio of voltage provided to the current flowing through it.

$$\boxed{R = \frac{V}{I}}$$

Resistor

- The resistor is the substance that reduces or limits the current passing through it.

~~Demontation~~

Demonstration of movement of electrons in conductors.

- Every materials are madeup of atoms which consists of electrons.
- These electrons move around the nucleus of their respective atom which produces random movement of them within the conductor.
- This random movement of electrons are meant to produce current but due to their direction, the average velocity of electrons within conductor is zero.

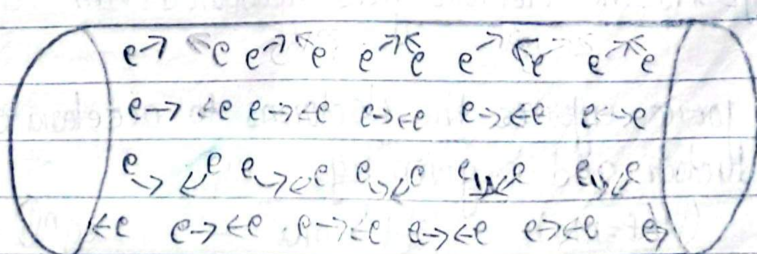


fig: conductor

→ When potential differences is applied across two end of the conductor, electrons present in material are oriented in same direction and gain certain amount of velocity.

→ This velocity that causes the electrons to move in a certain direction is known as drift velocity.

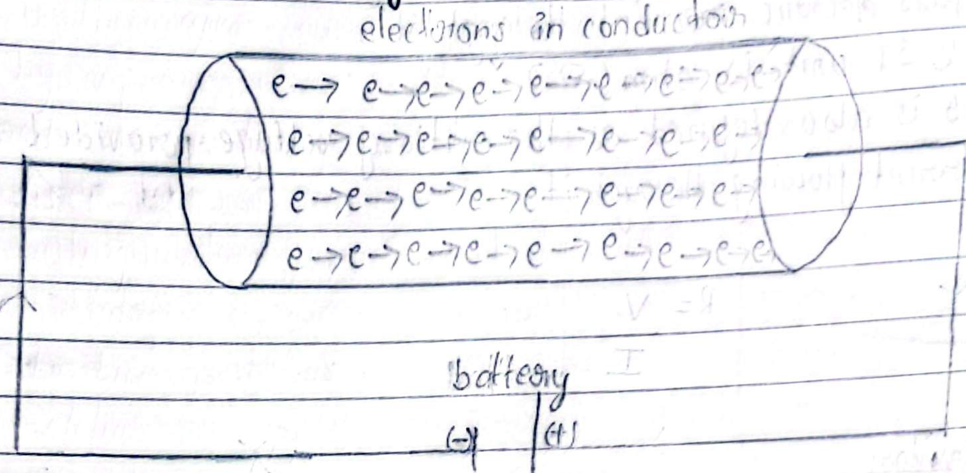


fig: drift velocity

→ Thus, we can say that ~~every~~ current produced in a conductor is due to drift current.

→ Drift current is produced due to the drift velocity of electrons from lower potential to higher potential.

Drift velocity derivation

When the potential difference is applied across the conductor, the electrons within a conductor experience force due to electric field and is given by

$$(F = -qE) \quad \boxed{F = -eE} \quad --- \text{eq}^n (i)$$

Where, E is the electric field measured V/m

These force enforce the electrons to accelerate across the conductor and is given by

$$(\text{W.K } F = mg) \quad \boxed{F' = ma} \quad --- \text{eq}^n (ii)$$

a = acceleration, m = mass

from eq^n (i) & (ii)

$$F = F'$$

or, $-eE = ma$

or, $\boxed{a = \frac{-eE}{m}}$ ---- eq^n (iii)

The velocity gained by electron is given by:- $\left(a = \frac{v-u}{t}\right)$

$\boxed{V = u + at}$ ---- eq^n (iv)

Since the average movement of electrons before we apply potential difference is zero $(u = 0)$, we can write:-

$$V = at$$

from eq^n (iii) we have, putting the value of a from eq^n (iv)

$\boxed{V = \left(\frac{-eE}{m}\right) \times t}$ V = drift velocity, e = charge of electron, E = electric field

Drift velocity is measured in meter per second (m/s)

The drift velocity of electrons is very small (in the range of 0.1m/s) with this velocity it will take almost 17 minutes for electron to pass through 1m conducting wire.

Here the term $\frac{eE}{m}$ is called mobility of electrons (μe).

It's unit is $m^2/V*sec$ (* multiply)

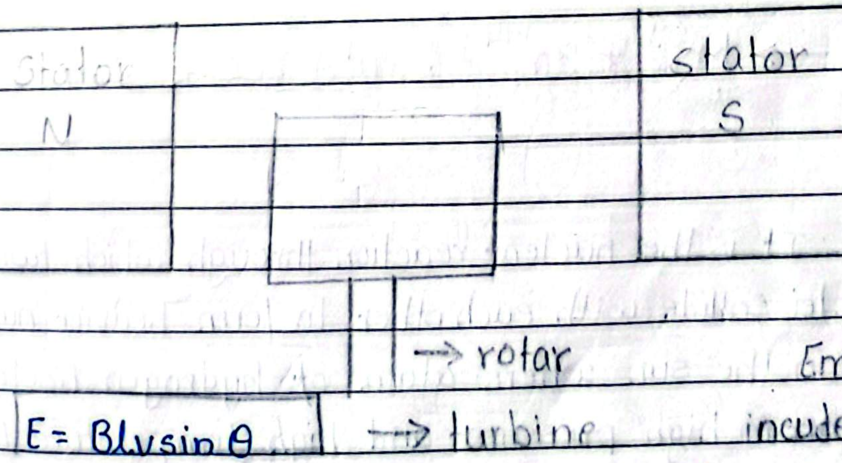
The current across the cross-section of wire due to drift velocity is given by:-

$\boxed{I = VenA}$ (Here I = current, V = drift velocity, e = charge of electron, n = no of electrons, A = cross-section)

Sources of Electricity

1 Hydro

- Hydropower is the electricity produced from generators driven by turbines that convert potential energy into kinetic energy. with the help of force of works.
- It is the mostly used source of electricity in Nepal.
- In generation of hydro electric power, water is stored at higher elevation.
- The stored water is then led downwards with the helps of large pipes or tunnel (Penstocks) to the lower elevation.
- The differences in elevation is called head.
- The falling water from penstocks hits the turbine which allows turbine to rotate.
- The turbine is then connected to generators which converts mechanical energy into electrical energy.
- Transformers are then used to convert the generated voltage into suitable higher voltage for transmission.
- The structure that have turbines, generators and into which penstocks are filled is called powerhouse.
- The electricity generated in generator is given by faraday's law of electro-magnetic induction.



Emf incuded due to moving conductor within in magnetic field.

$\boxed{E = Blv\sin\theta}$

E = Emf (Electromotive force) (voltage)

B = Magnetic field of stator

$$\boxed{emf = Blv\sin\theta}$$

Here, B = magnetic field strength.
l = length of conductor.
v = velocity of conductor.
θ = direction between conductor and magnetic field.

2. Nuclear Energy
→ Nuclear Energy is the energy present in nucleus of an atom.
→ The force due to nuclear energy are called strong force while the comparision of gravitational force are considered weak as nuclear.
→ Nuclear energy ~~were~~ are used to generated electricity by two process called as:
i) Nuclear fussion
ii) Nuclear fission

i) Nuclear fussion
→ It is the nuclear ~~fission~~ reaction through which two or more small / light nuclei collidewith each other to form ~~behaviour~~ heavier nucleus.
→ Fussion occurs in the sun where atoms of hydrogen (isotopes). Atom of hydrogen combine together in high pressure and high temperature to produce an isotopes of helium and a neutron.

MeV = mega electronvolt

d_2O = heavy water
h_2O = water

$$_1H^2 + _1H^3 \longrightarrow _2He^4 + _0n^1 + \underbrace{18\ MeV}_{\text{Energy}}$$

(deuterium) (tritium) (Helium) (neutron)

mass can't be destroy nor be created but it can pass from one body to another

ii) Nuclear Fission

→ It is an nuclear reaction in which nucleus of large atom is bombarded with low energy neutrons with splits the nucleus into small nuclei - During this process large amount of energy is released.

→ Nuclear fission reaction are used in nuclear power ~~reac~~ reactory, since it is easy to control and produce large amount of energy.

→ When uranium(235) is bombarded with slow moving neutron, the heavy atom nucleus of uranium splits and produce Krypton(89) and Barium atom (144) along with three ~~nuetron~~ atom neutron & energy.

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{36}Kr^{89} + {}_{56}Ba^{144} + 3\,{}_0n^1 + 200\,MeV$$

3) Solar Energy

→ Solar technology convert light energy into electrical energy either through photovoltaic pannels or through mass ~~conce~~ concentration of solar radiation.

→ This energy can be used to generate electricity and charge large batteries -

→ In such cell Photovoltaic pannels consists of solar cell or photovoltaic cell.

→ In such cell small electric voltage is generated when light strikes those cell. This called photovoltaic effect.

→ Photovoltaic cell consists of two-types semi-conductors placed in between metallic plates. This metallic plates are connected to batteries of load.

→ Negatively charged semi-conductor are called ntype semi-conductor and ~~p type~~ positively charged semi-conductor are called p type semi-conductor.

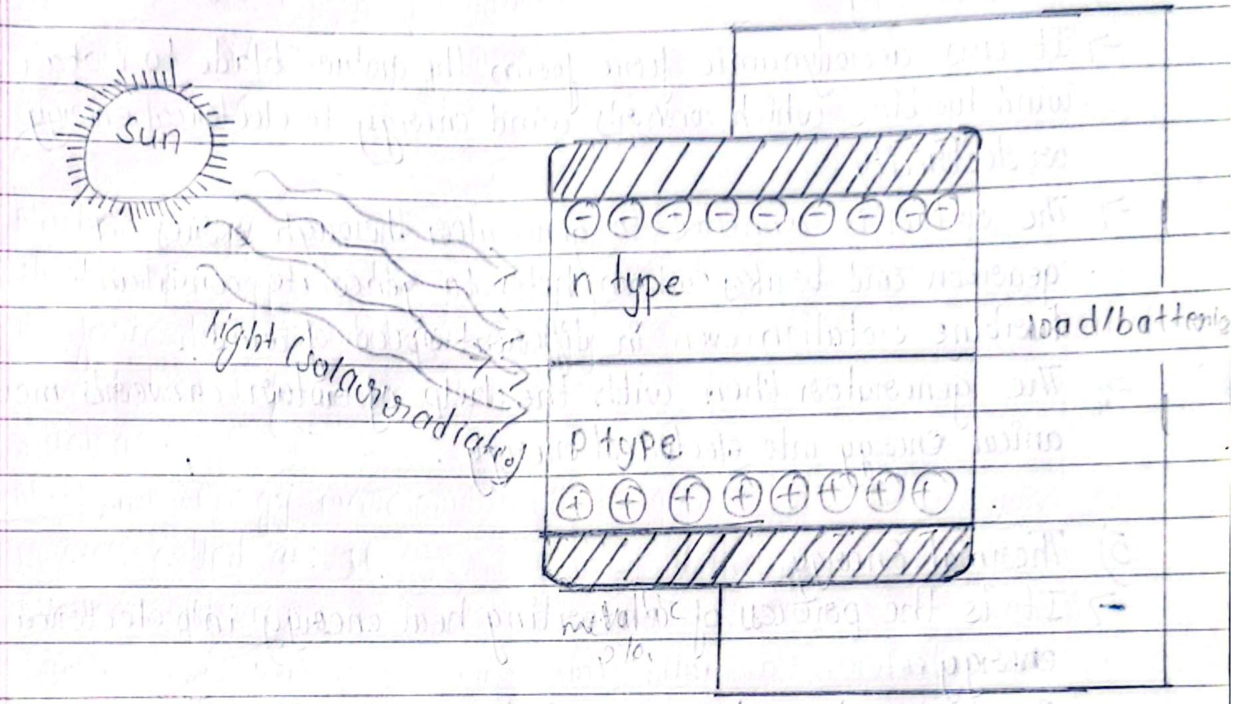


fig : photovoltaic cell

an act of joining

→ When the light ~~of~~ strikes the junctions between metal and semi-conductor or the junction between ~~metal and~~ semi-conductor (p type and n type), electric voltage is generated between two metallic plates. Due to emission of electrons and creation of holes. This is called photo electric effect.

→ Antireflective coating, transparent adhesive are used in solar pannel in order to receive maximum light.

→ The power generated by a single solar cell is two watts only.

→ The array of cell are connected together ~~Solar pannels are faced towards~~ south in order to generate electricity in large amount.

→ Solar pannel are faced towards south in order to get maximum sunlight

→ The dust solar pannel should be clean regularly to get maximum.

efficency.

4) Wind Energy
→ It uses aerodynamic force from the rotar blade to rotate wind turbine which converts wind energy to electorical energy or electricity.
→ The rotar is connected to generator through series of gearbon and brakes which helps to generate consistant turbine rotation even in different speed of wind.
→ The generator then with the help of rotar converts mechanical energy into electrical energy.

5) Thermal Energy
→ It is the process of converting heat energy into electrical energy.
→ A atemperature differencea between two dissimilar electorical conductor or semi-conductor produces voltage differene between two substance. It is also known as seebeck effect.

Flow of current
→ Flow of electoric current in an electoric circuit.
It is of two types.
i) Conventional flow of current
ii) Modern flow of current

Electoric circuit.

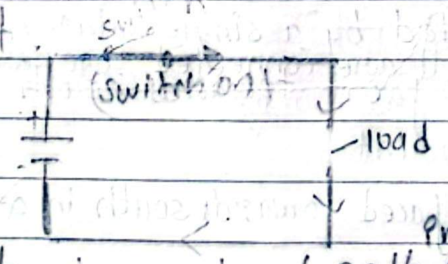


fig:- Electoric circuit.

electoric circuit is a closed path which have potential difference is generated and have electoric load (bulb, fan, tv) and switch.

The mobility of proton is less than electrons.

Particle: Those substance have mass is particles

1) **Conventional flow of current.**

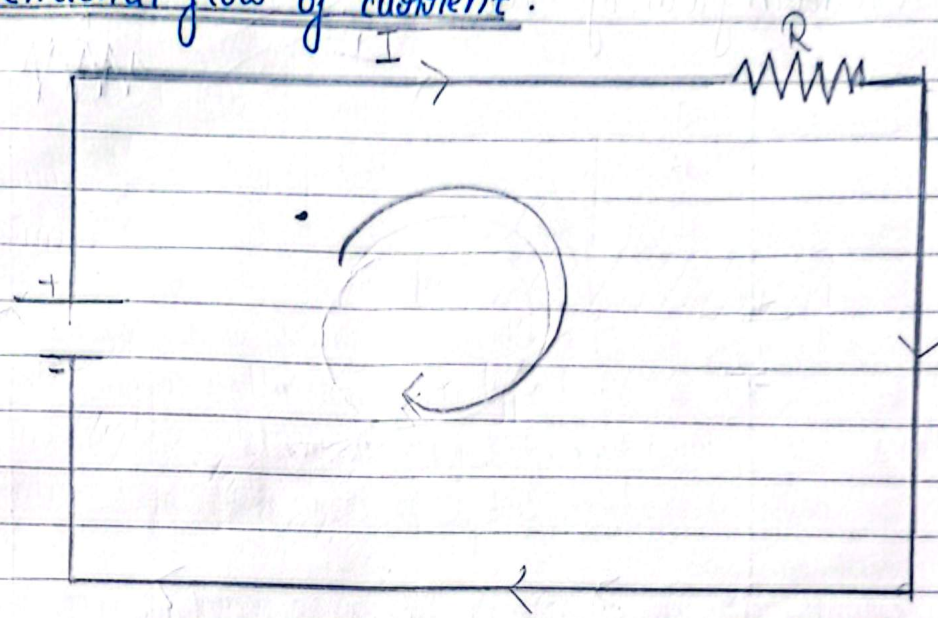


fig.- Conventional flow of current.

→ The assumption that positive charges flow from positive terminal to negative terminal is called conventional current.

→ Conventional current is standard that is followed all over the world.

→ Electric circuit produces result that are independent of current that is why this flow of current is steal in use.

2) Modern flow of current.

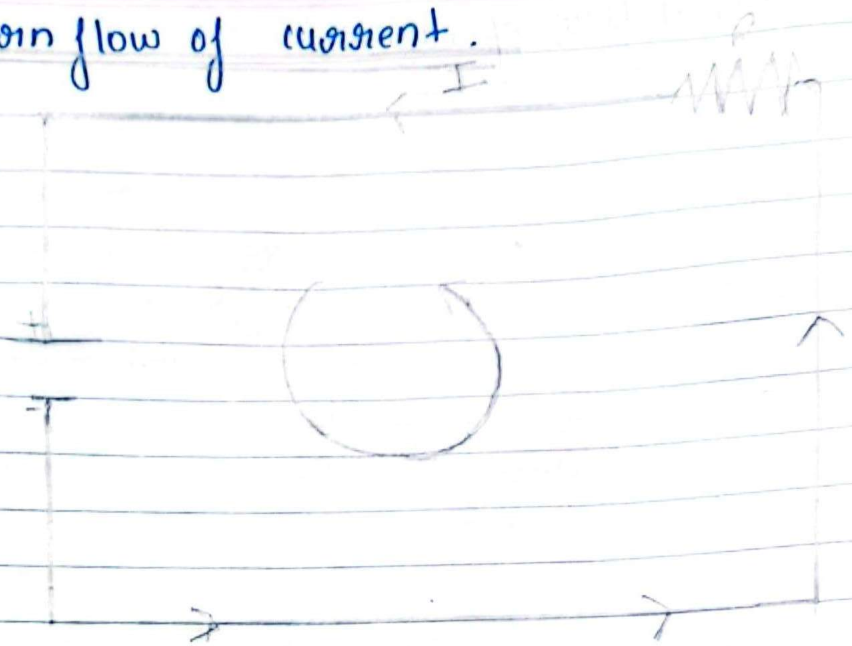


fig: Modern flow of current

→ The electron actually flows from negative potential to positive potential through circuit, such type of flow of current is called modern flow of current.

Use of resistor (advantage)

→ It limits the current and voltage in the circuit.

→ It is used as safety components in the electric circuit (eg:- fuse)

→ It is used as a current divider and voltage divider in the circuit

→ It is used in power supply to deliver constant and desirable power.

Factors affecting the value of resistance(R)

1) length of conductor(l)

→ Resistance of a conductor is directly proportional to the length of wire (longer the wire, greater is the resistance and shorter the wire, lower is the resistance.

i.e.

$R \propto l$ ---- eqn(i)

3) Thickness of conductor(A).

→ Resistance of conductor is inversely proportional to the thickness of conductor or cross-sectional area(A) of conductor.

i.e.

$R \propto \frac{1}{A}$ --- eqn(ii)

3) Material used.

→ Resistance of conductor depends upon the type of substance used.

Eg:- metal have low resistance in comparison to non-metal & metalloids

4) Temperature

→ Resistance of a conductor depends on the temperature of ~~metalloids~~ materials used

→ Resistance of a mejority of conductor increase with increase in temperature.

→ It is called positive temperature cofficient.

Combining eqⁿ (i) & (ii), we have

$R \propto \frac{l}{A}$

$\boxed{\text{or } R = \frac{\rho l}{A}}$

where, ρ (rho) is the resistivity of the material.
→ resistivity is the property of resistance that help resistance to limits current.
unit of ρ is Ωm.

Calculate the resistance of copper wire having length 5m and cross-sectional area $0.01m^2$ ($\rho_{cu} = 1.72 \times 10^{-8} \Omega m$)

Soln:

Given, length (l) = 5m
Area (A) = $0.01m^2$
resistivity (ρ) = $1.72 \times 10^{-8} \Omega m$
resistance (R) = ?

We know

$R = \frac{\rho l}{A}$

$= \frac{1.72 \times 10^{-8} \times 5}{0.01}$

$= \frac{1.72 \times 10^{-8} \times 5}{10^{-2}}$

$\cancel{= \frac{1.72 \times 10^{-8+2}}{1}}$ $= 8.6 \times 10^{-8+2}$

$= 8.6 \times 10^{-6} \Omega$

∴ Resistance of given copper wire is $8.6 \times 10^{-6} \Omega$ #

* Calculate the resistance of silver wire having length 8m and cross-sectional area 0.01mm² ($\rho_{Ag} = 1.59 \times 10^{-8}\ \Omega m$)

Soln:

Given,

length (l) = 8m

Area (A) = 0.01mm²

$$= \frac{0.01}{1000 \times 1000} m^2$$

$$= \frac{0.01}{10^3 \times 10^3} m^2$$

$$= \frac{0.01}{10^6} m^2$$

$$= 0.01 \times 10^{-6}\ m^2$$

$$= 1 \times 10^{-6\cancel{+2}-2}\ m^2$$

$$= 10^{-8} m^2$$

Resistivity (ρ) = $1.59 \times 10^{-8}\ \Omega m$

Resistance (R) = ?

We know,

$$R = \frac{\rho l}{A}$$

$$= \frac{1.59 \times 10^{-8} \times 8}{10^{-8}}$$

$$= \frac{12.72 \times \cancel{10^{-8}}}{\cancel{10^{-8}}}$$

$$= 12.72\ \Omega \#$$

∴ The resistance of silver wire is 12.72 Ω #

Calculate the resistance of iron wire having length 1.5Km cross sectional area $0.01 cm^2$ ($\rho_{Fe} = 10^{-7} \Omega m$)

Soln!

Given,

length (l) = 1.5 Km

$= 1.5 \times 1000 m$

$= 1500 m$

Area (A) = $0.01 cm^2$

$= \frac{0.01}{100 \times 100} m^2$

$= \frac{0.01}{10^4} m^2$

$= 0.01 \times 10^{-4} m^2$

$= 1 \times 10^{-4-2} m^2$

$= 10^{-6} m^2$

Resistivity (ρ) = $10^{-7} \Omega m$

Resistance (R) = ?

We know,

$R = \frac{\rho A}{l}$

$= \frac{10^{-7} \times 1500}{10^{-6}}$

$= 1500 \times 10^{-7+6}$

$= 1500 \times 10^{-1}$

$= 1500 \times 0.1$

$= 150 \Omega$

∴ The resistance of iron (Fe) is 150Ω #

Find the length of copper wire having cross-sectional wire $10^{-3}cm^2$ and resistance across it is measured to be $15\,\Omega$. $(\rho_{cu} = 1.72\times10^{-8}\,\Omega m)$

Soln:

Given,

length $(l) = ?$

Area $(A) = 10^{-3}cm^2$

$$= \frac{10^{-3}}{100\times100}\,m^2$$

$$= \frac{10^{-3}}{10^{4}}\,m^2$$

$$= 10^{\cancel{-3+4}\,-3-4}\,m^2$$

$$= 10^{-7}\,m^2$$

Resistance $(R) = 15\,\Omega$.

Resistivity $(\rho) = 1.72\times10^{-8}\,\Omega m$

We know,

$$R = \frac{\rho l}{A}$$

$$l = \frac{RA}{\rho}$$

$$\cancel{= 1.72\times10^{-8}\times10^{-7}}$$

$$= \frac{15\times10^{-7}}{1.72\times10^{-8}}$$

$$= 8.720\times10^{-7+8}$$

$$= 8.720\times10^{1}$$

$$= 87.20\cancel{\times1}\,m$$

$$R = \frac{\rho l}{A}$$

or, $15 = \dfrac{1.72\times10^{-8}\times l}{10^{-7}}$

or, $\dfrac{15\times10^{-7}}{1.72\times10^{-8}} = l$

or, $l = 8.720\times10^{-7+8}$

or, $l = 8.720\times10^{1}$

$\therefore l = 87.20m$ #

$\therefore$ The length of copper wire ~~has~~ is $87.20\,m$ #

Find the resistance of silver wire having length 0.5m and radius 0.7mm ($\rho_{Ag} = 1.59 \times 10^{-8} \Omega m$)

Soln

Given,

length (l) = 0.5m

radius (r) = 0.7 mm

$= \frac{0.7}{1000}$ m

$= 7 \times 10^{-4}$ m

Area (A) = πr^2

$= \frac{22}{7} \times (7 \times 10^{-4})^2$

$= \frac{22}{\cancel{7}} \times 7^{\cancel{2}} \times 10^{-8}$ m^2

$= 154 \times 10^{-8}$ m^2

Resitance (R) = ?

We know,

$R = \frac{\rho l}{A}$

$= \frac{1.59 \times \cancel{10^{-8}} \times 0.5}{154 \times \cancel{10^{-8}}}$

$= \frac{0.795}{154}$

$= 5.162 \times 10^{-3}$ ~~m~~Ω

∴ The resistance of silver ~~wire having~~ wire is 5.162×10^{-3} ~~m~~Ω #

What will be the change in resistance of copper wire if it is elongated to twice its length and area is decreased by $\frac{3}{4}$th of its original area ($\rho_{cu} = 1.72 \times 10^{-8}\,\Omega m$)

Soln:

Given,

Case I ~~length~~:

length $= l_1$

Area $= A_1$

Resistance $= R_1$

We know,

$$R = \frac{\rho l_1}{A_1}$$

Case II

length $= l_2 = 2l_1$

Area $= A_2 = \frac{3}{4} \times A_1$

Resistance $= R_2$

Now,

$$R_2 = \frac{\rho l_2}{A_2}$$

$$\text{or } R_2 = \frac{\rho \cdot 2l_1}{\frac{3A_1}{4}}$$

$$= \frac{8}{3} \times \frac{\rho l_1}{A_1}$$

$$= \frac{8}{3} \times R_1 \; \cancel{\Omega}$$

$\therefore$ The Resistance of copper wire change by $\frac{8}{3}$ times #

What will be the change in resistance of a wire if it is cut down from its half point.

Soln:

Case I

length $= l_1$

Area $= A_1$

Resistance $= R_1$

Now,

$$R = \frac{\rho l_1}{A_1}$$

Case II

length $= l_2 = \frac{1}{2} \times l_1$

Area $= A_2 = A_1$

Now,

$$R_2 = \frac{\rho l_2}{A_2} = \frac{\rho \times \left(l_1 \times \frac{1}{2}\right)}{A_1} = \frac{1}{2} \times \frac{\rho l_1}{A_1}$$

$\therefore R_2 = \frac{1}{2} \times R_1$

$\therefore$ The resistance of wire change by $\frac{1}{2}$ times.

What will be the change in resistance of wire if it is elonget to three times of its original length and the diameter of a wire is decrease by 2 times.

soln:

Case I

Resistance $= R_1$

length $= l_1$

diameter $= d_1$

Area $= A_1 = \pi r^2 = \pi \left(\frac{d}{2}\right)^2$

We know,

$$R_1 = \frac{\rho l_1}{A_1} \quad --- \text{ eq}^n(i)$$

Case II

Resistance $= R_2$

length $= l_2 = 3l$

diameter $= d_2 = \frac{d_1}{2}$

$$\text{Area} = A_2 = \pi r^2 = \pi \left(\frac{d_2}{2}\right)^2$$

$$= \pi \left(\frac{d_1}{2 \times 2}\right)^2$$

$$= \frac{1}{2^2} \pi \left(\frac{d}{2}\right)^2$$

$$= \frac{1}{4} \pi \left(\frac{d^2}{2}\right)^2$$

$$= \frac{1}{4} \times A_1$$

We know

$$R_2 = \frac{S l_2}{A_2}$$

or, $R_2 = \frac{S \cdot 3 \cdot l_1}{\frac{1}{4} \cdot A_1}$

$$= \frac{12}{1} \times \frac{S l_1}{A_1}$$

$$= 12 \times R_1$$

$\therefore R_2 = 12 R_1$

$\therefore$ The change is resistance is by 12 times.

What will be the change in resistance if length of a wire is quadrupled and its diameter is decreased by 3 times? Also calculate the new resistance of original resistance of ~~wirete ce~~ wire was 5Ω.

Soln:

Case I

length $= l_1$
Resistance $= R_1$
diameter $= d_1$
Area $= A_1 = \pi r^2 = \pi \left(\frac{d}{2}\right)^2$

Now, $R_1 = \frac{S l_1}{A_1}$ ------ eq^n(i)

Case II

length $= l_2 = 4l$
Resistance $= R_2$
diameter $= d_2 = \frac{d_1}{3}$

$$\text{Area} = A_2 = \pi r^2 = \pi \left(\frac{d_2}{2}\right)^2$$

$$= \pi \left(\frac{d_1}{3\times 2}\right)^2$$

$$= \frac{1}{3^2}\pi\left(\frac{d}{2}\right)^2$$

$$= \frac{1}{9} \cdot A_1$$

We know,

$$R_2 = \frac{S l_2}{A_2}$$

$$= \frac{S 4 l_1}{\frac{1}{9} A_1}$$

$$= \frac{36}{1} \frac{S l_1}{A_1}$$

$$= 36 \cdot R_1$$

$\therefore R_2 = 36 R_1$ ——— eq^n(iii)

$\therefore$ The change in Resitance is by 36 times.

Again, Putting the vaule of R_1 in eq^n(ii)

$$R_2 = 36 \cdot R_1$$

$$= 36 \times 5$$

$$= 180\,\Omega$$

$\therefore$ The new resistance of wire is $180\,\Omega$.

CamScanner

Classification of materials on the basis of resistance.

1. Conductor
2. Semi-conductor
3. Insulator.

1. Insulator.

-> Those substances which do not allow the electric current to flow through them easily are called ~~conductor~~. insulator.

-> Example:- plastic, wood, rubber, glass etc.

-> Resistance of the substance are very high as electron present in the valenced band require very high energy to get into conduction band. It protect us from electric

It's valenced band and conduction band have maximum electric gap.
(outermost shell)

2) Conductor

-> Those substances which allow the electric current to flow through them very easily due to presence of large no. of free electrons are called conductor. for example:- Copper, Iron, Silver, Gold, Aluminium etc.

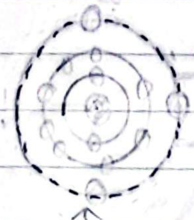
-> It ~~offers~~ occurs very low resistance because the free electrons in valenced band can easily pass into conduction band.

-> The valenced band and conduction band are overlapped in conductor.

It's valenced and conduction band have very less electric gap or overlapped.

For ex: Atomic structure of Al

If we apply certain energy, the free electron in valenced band can easily pass into conduction band.



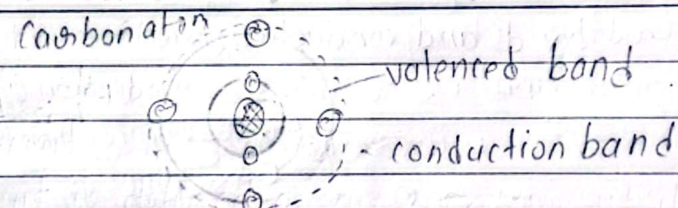
3. **Semi-Conductor.**

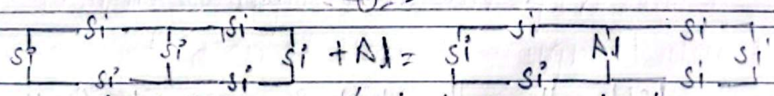
→ Those substances which have conductivity between insulator and conductor are called semi-conductor. For example = Metalloids (silicon, carbon, etc).

→ At room temperature, they have electorical electorical conductivity lower than that of conductor and higher than that of insulator.

→ The main property of semi-conductor is that its electorical conductivity can be increased by adding impurest like Aluminium, Boron etc. This porocess is called doping.

It have minimum gr electric gap between valence band and conduction band.





Doping

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Difference between resitance and resistivity.

S.N	Ressistance	S.N	Resistivity.
i)	It is the measurement of dificalty of pass electric current through material	i)	It is the property of material that determines the resistance of substances having unit length and unit area.
ii)	It's unit is Ohm.	ii)	It's unit is Ohm meter.
	~~Con~~		

Conductance

→ It is the measurement of easyness of passing electric current through the material.

→ It's unit is $\mho$/mho (Seiemen)