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Where Minds Pollinate

Class 11
Physics

Chapter 11

Handwritten Notes

CHAPTER # 11
Electricity

current:

Rate of flow of charge through the cross section of conductor is called current. It's the amount of charge passing through the cross-section of conductor in one second.

Formula:

$$I = \frac{Q}{t}$$

$$I = \frac{C}{s} = Cs^{-1} = \text{Ampere} = A$$

current is represented by I. It's a scalar quantity.

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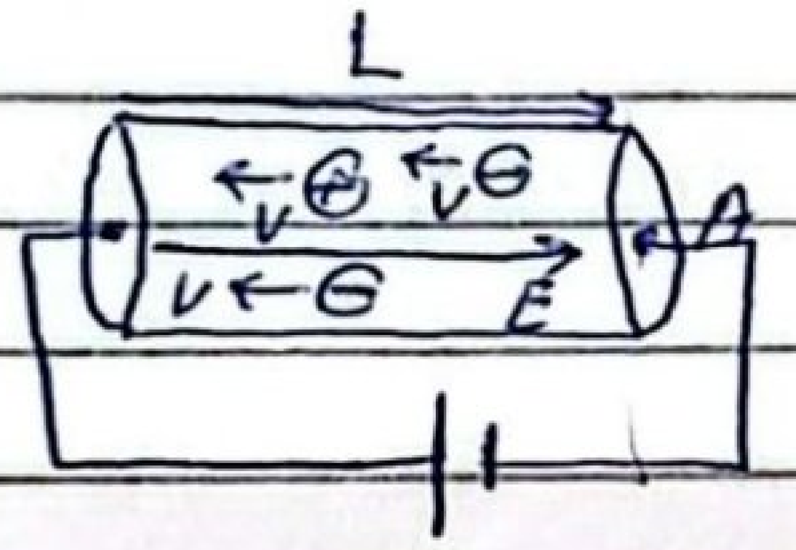
Drift velocity (V_d):

When potential difference is applied across the ends of a conductor. It produces an electric field inside the conductor. This electric field drift the electron from low potential region to the higher potential region with a small constant velocity ($10^{-3}\ ms^{-1}$). This small constant velocity is called drift velocity. It's represented by V_d

Diagram:



Derivation:

volume of conductor = $V = AL$

electron density = n

No. of electrons in conductor = nAL

Charge in conductor = $nALe$

Therefore,

$$Q = nALe$$

÷ b/s by t

$$\frac{Q}{t} = \frac{nALe}{t}$$

$$I = nA\left(\frac{L}{t}\right)e$$

$$I = nAV_de$$

$$\boxed{V_d = \frac{I}{nAe}}$$

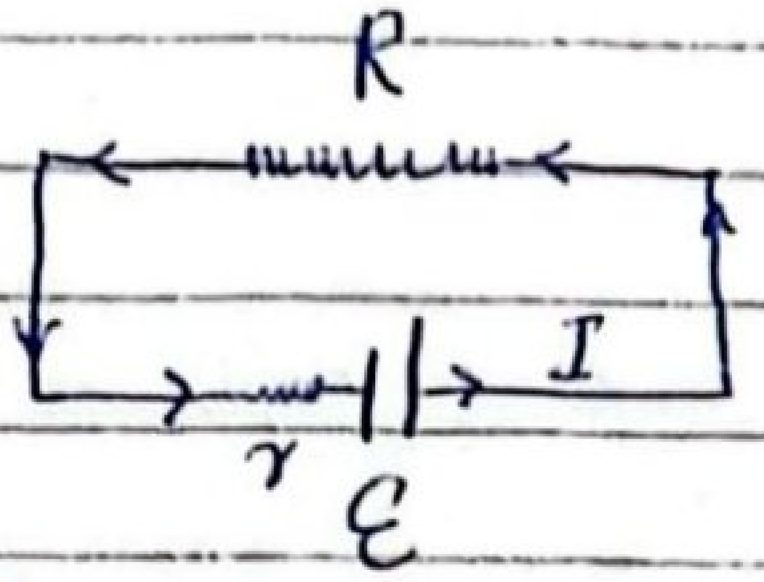
Dependence of drift velocity:
Drif velocity of electrons in a conductor depends upon the following factors
1- Length of the conductor
2- potential difference across the ends of conductor.
3- Temperature of the conductor.

Electromotive force (emf)
The amount of energy suppeied by a cell or battery to one colomb charge when unit charge goes from negative terminal to positive terminal of cell is called emf of cell. It's represented by $\mathcal{E}$. Its SI unit is JC^{-1} or volt.
→ It's actually energy not a force.

Internal Resistance (r):
The amount of opposition present inside the battery due to the electrolyte when charge go from negative terminal of the cell to the positive terminal of cell is called internal resistance. It's represented by "r". It's unit is ohm (Ω) The energy consumed by internal energy is "Ir."

Terminal potential difference:
The potential difference across the terminals of cell/battery is called terminal potential difference. It's the amount of the energy supplied by the cell/battery to the load (R). It's represented by V. Its value is $V = IR$
Its unit is JC^{-1} or volt.

Relationship b/w emf and terminal potential difference:



A/c to the law of conservation of energ.

$$\varepsilon = Ir + IR$$
$$\varepsilon = Ir + V$$
$$\varepsilon = Ir + V$$
$$V = \varepsilon - Ir$$

Similarly,

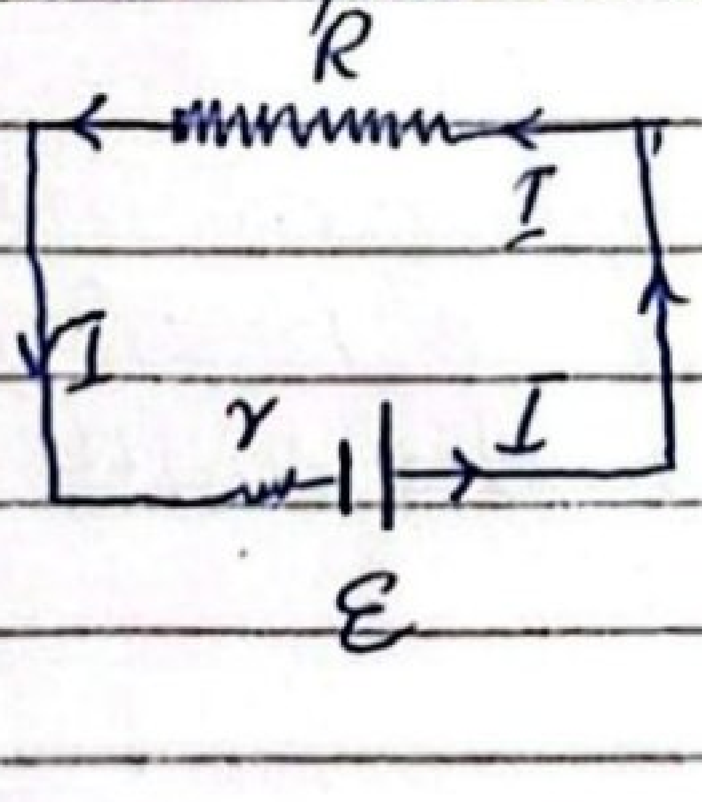
$$\varepsilon = Ir + IR$$
$$= I(r+R)$$
$$I = \frac{\varepsilon}{r+R}$$

Maximum power transfer theorem:

Definition:

The power transfer by a source of emf to the load (R) is maximum only when internal resistance of source of emf is equal to the load resistance (R). This statement is called maximum power transfer theorem.

Diagram:



Proof

power consumed by load resistor is given by;

$$P_o = I^2 R$$

$$= \left(\frac{\mathcal{E}}{R+r}\right)^2 R = \frac{\mathcal{E}^2 R}{(R+r)^2}$$

$$P_o = \frac{\mathcal{E}^2 R}{R^2+r^2+2Rr+2Rr-2Rr}$$

$$P_o = \frac{\mathcal{E}^2 R}{(R-r)^2+4Rr}$$

power transfer to load resistor will be maximum only when;

$$(R-r)^2 = 0$$

$$R-r = 0$$

$$\boxed{R = r}$$

corresponding maximum power reeived by the load resistor is given by

$$(P_o)_{max} = \frac{\mathcal{E}^2 R}{(R-R)+4RR}$$

$$(P_o)_{max.} = \frac{\mathcal{E}^2 R}{4R^2} = \frac{\mathcal{E}^2}{4R} = \frac{\mathcal{E}^2}{4r}$$

Q.5 what is resistance? on what factors does it depends?
the measure of opposite to the flow of current through a conductor is called resistance. It's represented by R.

Formula:

Formula for the resistance of a conductor is given by

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

Unit:

By the definition of resistance

$$R = \frac{V}{I} = \frac{Volt}{Ampere} = \frac{V}{A} = VA^{-1} = ohm = \Omega$$

Factors affecting resistance of conductor:

Experimentally it has been observed that

$$R \propto L \longrightarrow (i)$$

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

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

$$R = const\ \frac{L}{A}$$

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

Where "ρ" is the constant of proporrnality called resistivity of the conductor. From the expression of resistance it is clear that the resistance of conductor is directly proportional to the length and inversley proportional to the cross-sectional area of conductor and also depends upon nature and temperature of conductor.

Q# What is resistivity? Write its unit and dependence.

Resistance of conductor of "1m" length and "1m²" area of cross section is called resistivity of conductor.

It's represented by ρ.

Formula,

ivo Y19s

Resistivity is given as:

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

Unit:

A/c to the formula,

$$\rho = RA/L$$

$$= \Omega m$$

Dependence:

Resistivity is the property of a material. It doesn't depend upon length and area of conductor. It depends upon the nature and temperature of material only.

Q#4 What is conductivity? Write its unit and dependence.

Definition:

The reciprocal of resistivity is called conductivity. It's the property of the material to allow flow of charges through it easily. It's represented by the symbol δ (sigma).

Formula:

By definition of conductivity

$$\text{conductivity} = \frac{1}{\rho} = \frac{1}{\frac{RA}{l}} = \frac{l}{RA}$$

Unit:

By the formula

$$\delta = \frac{1}{\rho} = \frac{1}{\Omega \cdot m} = \Omega^{-1} m^{-1} = \text{sie}$$

Dependence:
conductivity is the property of a material and depends only the nature and temperature of material of material. It doesn't depend upon the length and area of the conductors material.

Q# Describe the dependence of the resistance on temperature of conductor.
Suppose initial resistance and temperature of a conductor are T_1 and R_1. Similarly final resistance and temperature of conductor are T_2 and R_2 therefore,

$$\Delta T = T_2 - T_1$$
$$\Delta R = R_2 - R_1$$

experimentally it was observed that

$$\Delta R \propto \Delta T \longrightarrow (1)$$
$$\Delta R \propto R_1 \longrightarrow (2)$$

Combining (1) and (2)

$$\Delta R \propto R_1 \Delta T$$
$$\Delta R = \text{constant } R_1 \Delta T$$
$$\Delta R = \alpha R_1 \Delta T$$

Here "α" is the constant of proporonality called thermal coefficent of resistance.

Q# what is the thermal co-efficent of resistance?
It's the change in per ohm resistance of a conductor on changing the temperature of conductor by $1C^\circ$/K Its SI unit is K^{-1} or $C^{-\circ}$

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Formula:

$$\alpha = \frac{\Delta R}{R_1 \Delta T} = \frac{R_2 - R_1}{R_1 \Delta T}$$

Electrical power (P):

Defination:

The rate at which energy is being supplied or consumed by a circuit element / component is called electrical power. It's represented by P. Its SI unit is Js^{-1} or watt = W

Mathmatically:

suppose "Q" amount of charge passes through a potential difference "V" then,

$$W = QV$$

$$P = \frac{W}{t} = \frac{QV}{t} = \frac{Q}{t} \times V$$

$$\boxed{P = VI}$$

Similarly,

$$P = VI = (IR)I = I^2R$$

And,

$$P = VI = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$$

Electrical energy:

Definition:

Amount of energy required by a charged particle to move from one location to another location is called electrical energy. It's represented by "E". Its SI unit is "J"

Mathmatically,

$$P = \frac{W}{t} = E/t \Rightarrow E = P \times t$$

$E = P \times t$

$= (VI)t = VIt = I^2Rt = \frac{V^2}{R}t$

What is kilowatt hour?

Amount of energy supplied or consumed by a circuit element of "1000W" in one hour is called kWh. It's the unit of energy.

Relationship b/w kWh and joule

$1kWh = 1 \times 1000\ J/s \times 3600\ s$

$= 3600000\ J$

$= 3.6 \times 10^6\ J = 3.6\ MJ$

Kirchoff's current law (KCL):

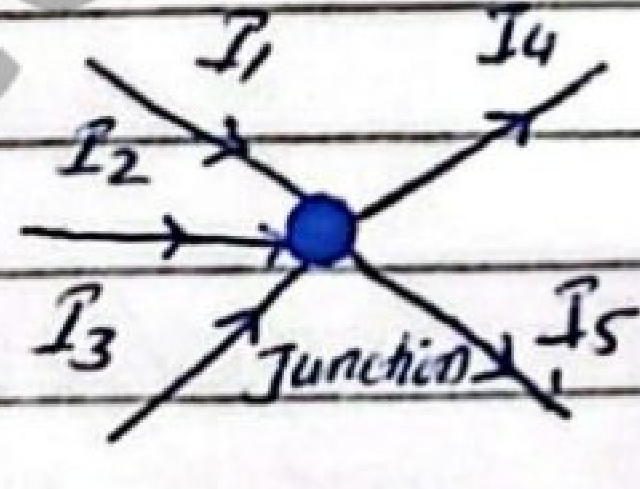
Definition:

Sum of all the currents entering the junction is equal to equal to the sum of all the currents leaving the junction This statement is called KCL.

principle:

KCL is based on law of conservation of charge.

Diagram:



Mathmatically:

$I_1 + I_2 + I_3 = I_4 + I_5$

Show that Kirchoff's law is based on law of conservation of ~~energy~~ of charge.

By definition of Kirchoff's current law, we have

$$I_1+I_2+I_3=I_4+I_5$$

$$\frac{Q_1}{t}+\frac{Q_2}{t}+\frac{Q_3}{t}=\frac{Q_4}{t}+\frac{Q_5}{t}$$

$$\cancel{\frac{1}{t}}(Q_1+Q_2+Q_3)=\cancel{\frac{1}{t}}(Q_4+Q_5)$$

$$Q_1+Q_2+Q_3=Q_4+Q_5$$

charges entered junction = charges left junction

What is photo-resistor (LDR)? Write its principle, construction types and uses.

Definition:

A device/resistor whose resistance change with the intensity of light falling on it is called light dependent resistor.

construction:

It's made up of any semi-conductor material such as silicon or Germinium.

principle:

It works on the principle of Photoconductivity.

Types of LDRs:

There are two types of LDRs

→ Intrinsic LDR

→ Extrinsic LDR

A- Intrinsic LDR:

An LDR which is made up of pure semi-conductor such as silicon or Germinium is called intrinsic LDR. It's is sensitive to all kind of the wavelength.

B- Extrinsic LDR:
An LDR which is made up of impure semi-conductor (Doped Semi-conductor) is called extrinsic LDR. It's sensitive to longer wavelengths only but not sensitive to the shorter wavelengths.

Uses of photoresistors:

1- Photo resistors are used in automation systems to reduces human efforts such as automatic street light systems.
2- They are used as potential divider in a circuit.
3- They are used to avoid unnessary power dissipation in circuits.

Kirchoff's loop Law (KVL)

Definition:
The algebric sum of all the changes in potential while moving in closed loop remain zero. This statement is called kirchoff's loop law (2nd law) voltage law.

principle:
Kirchoff voltage law is based on the law of conservation of energy.

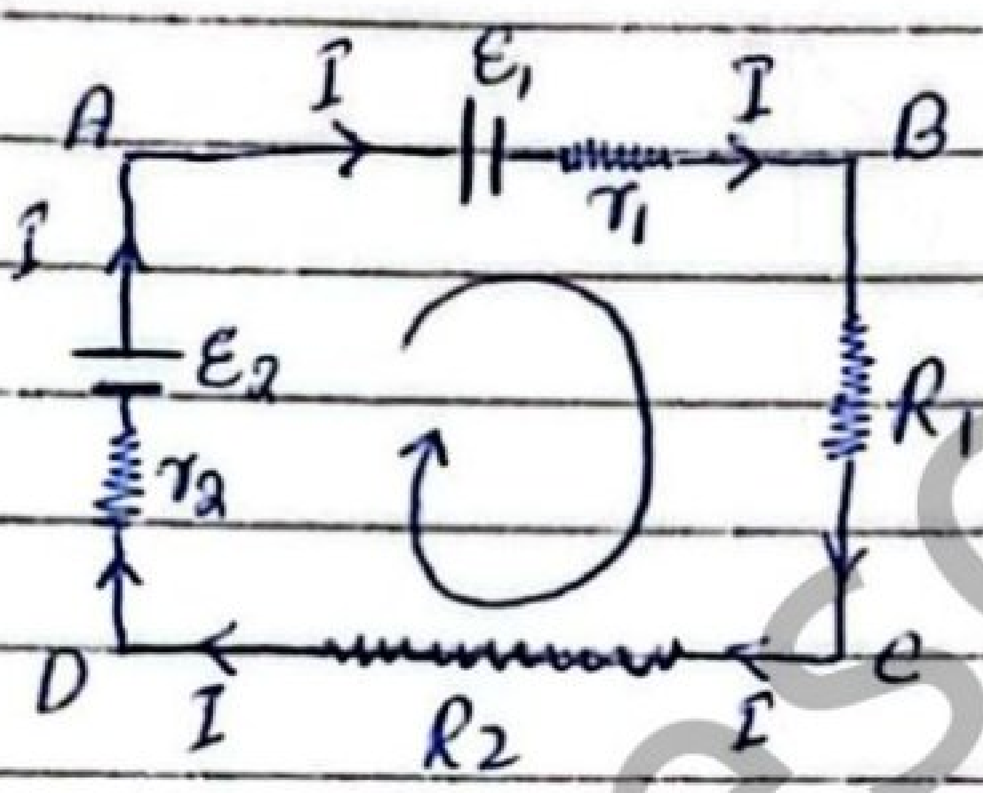
Sign convention:
While applying kirchoff second law, following sign conventions must be kept in mind.
(A) While going from high potential to low potential, change in potential is taken as negative ($\Delta V = -ve$)
(B) While going from negative to positive terminal change

in potential is taken as positive ($\Delta V = +ve$).

c) While going from lower potential to higher potential change in potential is taken as positive ($\Delta V = +ve$).

D) While going through a resistor, direction opposite to the current, change in potential is taken as positive ($\Delta V = IR$) otherwise negative ($\Delta V = -IR$)

Diagram:



Mathmatically:

Apply KVL on Loop ABCDA

$$(\Delta V)_{\mathcal{E}_1} + (\Delta V)_{r_1} + (\Delta V)_{R_1} + (\Delta V)_{R_2} + (\Delta V)_{r_2} \mp (\Delta V)_{\mathcal{E}_2} = 0$$

$$-\mathcal{E}_1 - Ir_1 - IR_1 - IR_2 - Ir_2 + \mathcal{E}_2 = 0$$

$$+\mathcal{E}_2 - \mathcal{E}_1 - Ir_1 - Ir_2 - IR_1 - IR_2 = 0$$

Wheatstone bridge:

Definition:

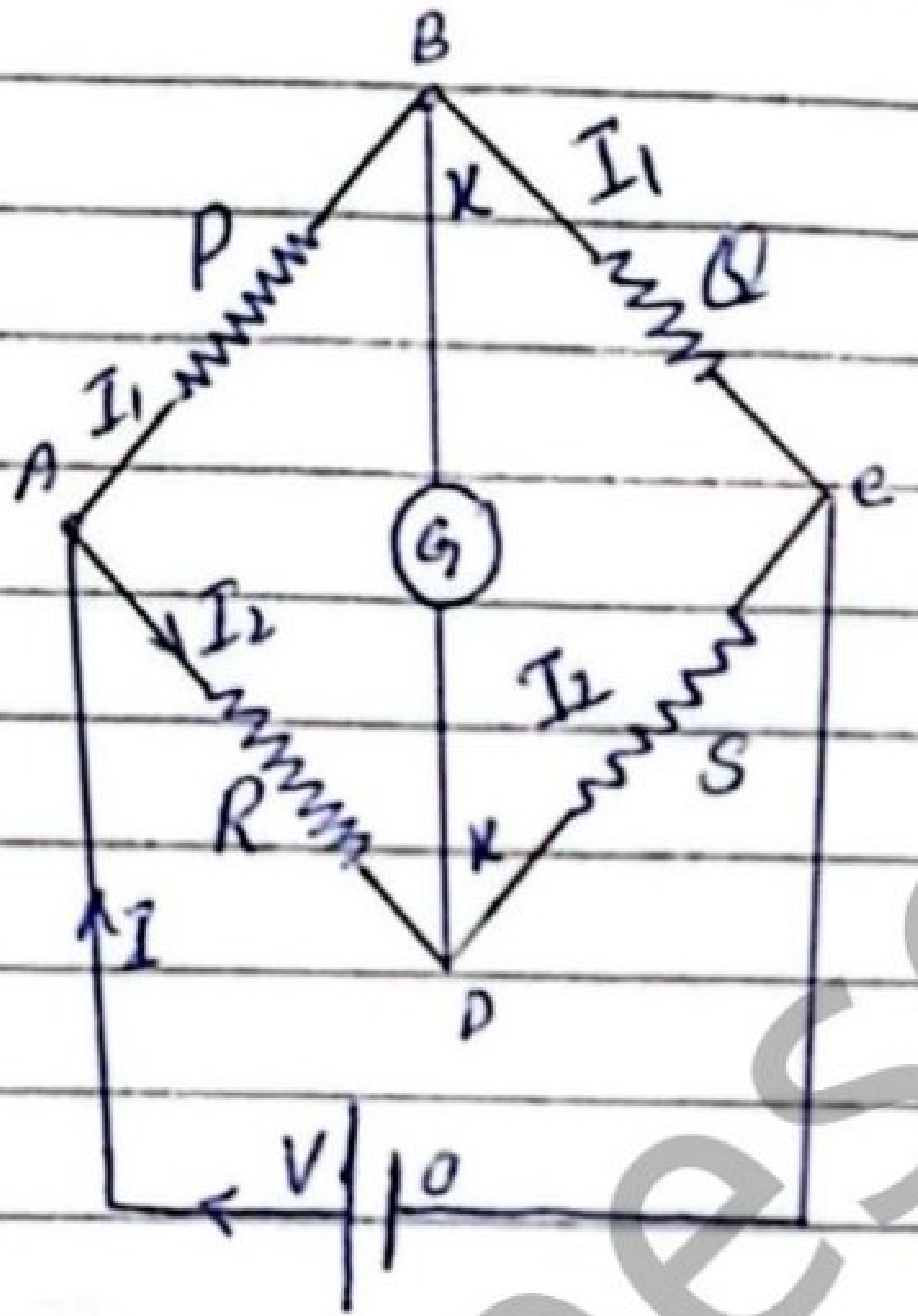
A device which is used to calculate the unknown resistance accurately is called Wheatstone bridge.

construction:

It consist of four resistors out of which three are known, a cell and a galvanometer.

Principle:
It works on no deflection method or null point method.

Diagram:



Balanced Wheatstone Bridge.
When potential of both ends of the galvanometer is same, no current passes through it. This state is called balanced wheatstone bridge.

Mathmatically:
A/c to ohm's law

$V - x = I_1 P$ —— ①

$V - x = I_2 R$ —— ②

Comparing one and ②

$I_1 P = I_2 R$

$\frac{I_1}{I_2} = \frac{R}{P}$ —— Ⓐ

Again A/c to ohm's law

$X - 0 = I_1 Q$ —— ③

$X - 0 = I_2 S$ —— ④

comparing ③ and ④

$I_1 Q = I_2 S$

$\frac{I_1}{I_2} = \frac{S}{Q}$ —— Ⓑ

comparing Ⓐ and Ⓑ

$\frac{R}{P} = S/Q$

$\boxed{R = S/Q \times P}$

Series combination of resistors:

Definition:

When two or more than two resistors are connected end to end, this type of combination is called series combination of resistors.

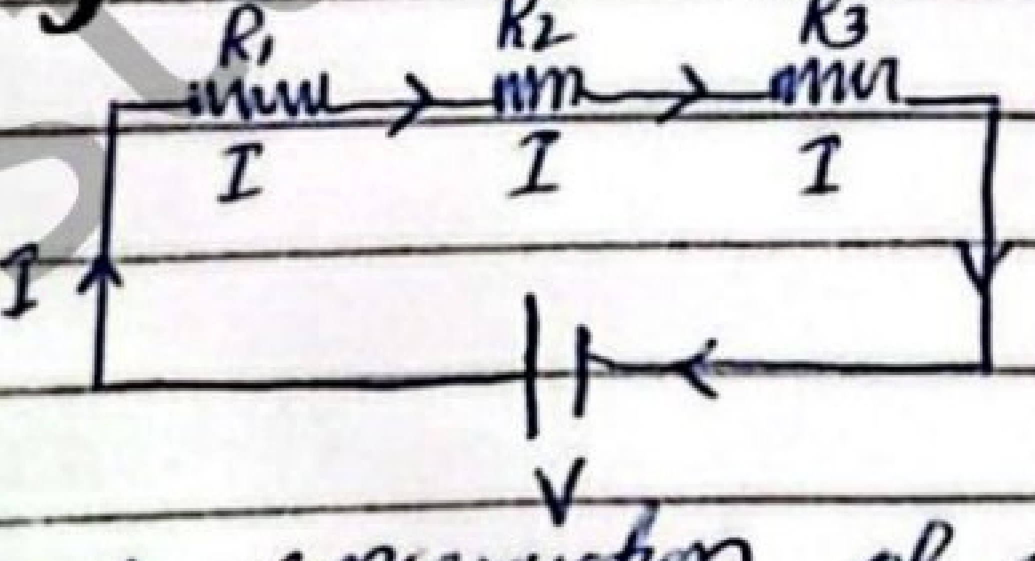
properties:

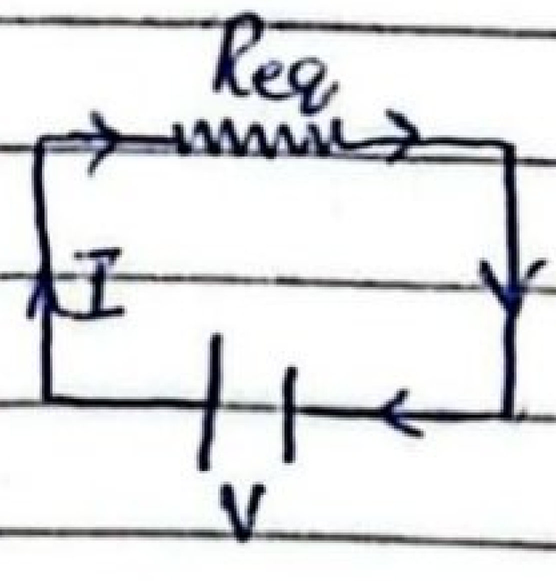
In series combination of resistors:

→ current through each resistor is same

→ voltage of cell is divided among all the resistors of combination.

Diagram:





A/c to conservation of energy.

$V = V_1 + V_2 + V_3$

$IR_{eq} = IR_1 + IR_2 + IR_3$

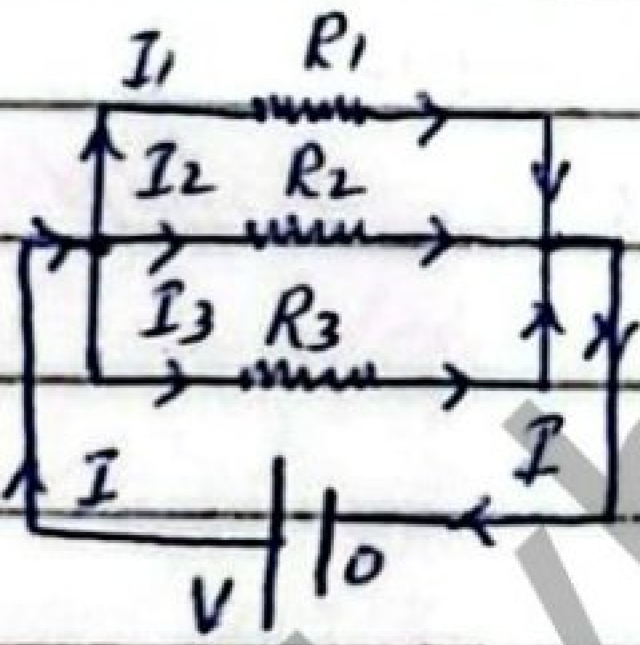
$IR_{eq} = I(R_1+R_2+R_3)$
$R_{eq} = R_1+R_2+R_3$

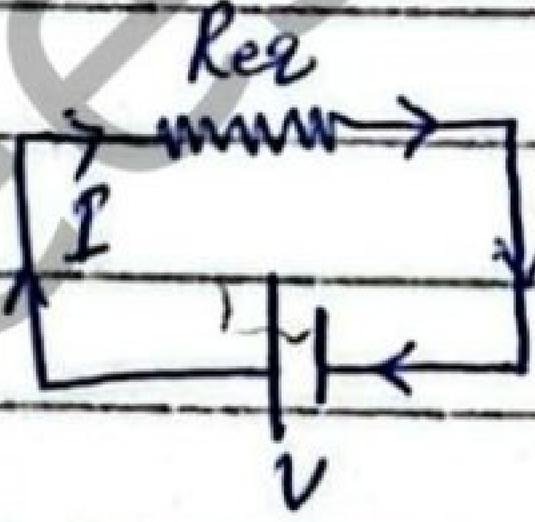
Parallel combination of resistors:

Definition:
When two or more than two resistors are connected such that each resistor is directly linked with cell/battery is called parallel combination of resistors.

properties:
In parallel combination of resistors:
→ current through each resistor is different
→ potential difference/voltage a/c each resistor is same.

Diagram





Mathmatically:

$I = I_1+I_2+I_3$

$\frac{V}{R_{eq}} = \frac{V}{R_1}+\frac{V}{R_2}+\frac{V}{R_3}$

$\frac{\cancel{V}}{R_{eq}} = \cancel{V}\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right)$

$1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3$

$\frac{1}{R_{eq}} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$

potentiometer

Definition:

A device which is used to measure the emf of cell, internal resistance of a cell, compare emfs of two cells and to measure the potential difference b/w two points accurately is called potentiometer.

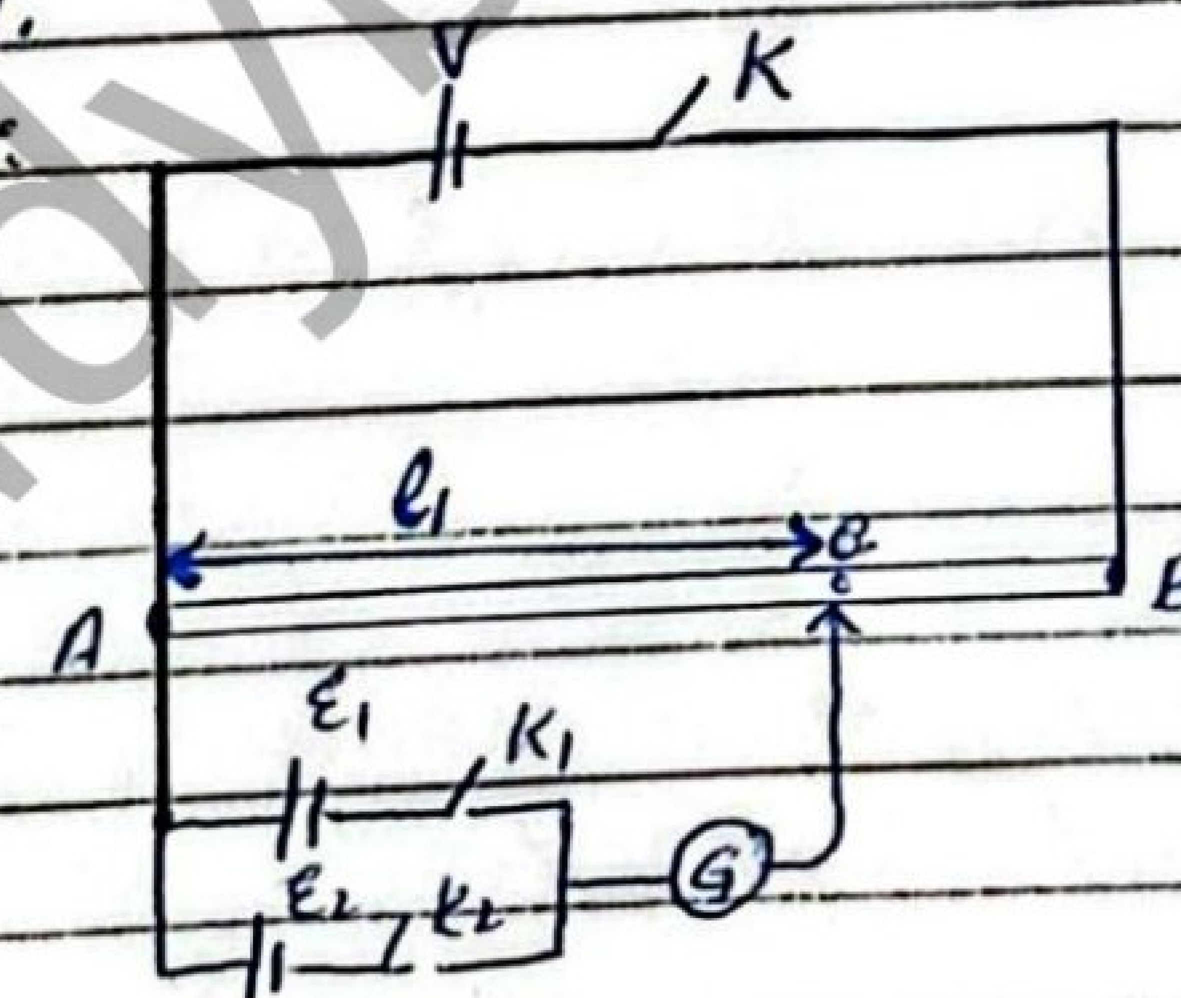
Construction:

It consist of a long wire of uniform area of cross-section connected with a battery/cell of voltage "V". The ratio of potential difference across wire and length of wire is called potential gradient. i.e $K = \frac{V}{l}$

Principle:

In potentiometer, an unknown potential difference is balanced against a known potential difference and measured.

Diagram:



Working:

Key "K_1" is closed keeping key "K_2" open and no deflection point is searched which is obtained at poin C. Therefore

$$\mathcal{E}_1 = Kl_1 \longrightarrow (1)$$

Now, key K_1 is opened and key K_2 is closed and again null point is searched which is obtained at poin "C" and length l_2.

$$\mathcal{E}_2 = Kl_2 \text{ --- } ②$$

Dividing ② by ① we get.

$$\frac{\mathcal{E}_2}{\mathcal{E}_1} = \frac{Kl_2}{Kl_1}$$

$$\mathcal{E}_2 = \left(\frac{l_2}{l_1}\right)\mathcal{E}_1$$

$$\mathcal{E}_2 = \frac{L_2}{L_1} \times \mathcal{E}_1$$

Application of potentiometer:

potentiometer is used to:

1- measure emf of a cell.
2- measure a potential difference b/w two points accurately than voltmeter.
3- compare emf of two cells
4- Measure the internal resistance of a cell.

Thermister

Definition:

A device/resistor whose resistance change with the temperature is called thermister.

Composition:

A thermistor consist of a semi-conducting material such as iron, nickle or cobalt oxides with two platinium leads and whole arrangement packed in in a glass case of any shape such as spherical or circular.

Types of thermistor

There are two types of thermistor.

1- Negative temperature coefficent thermistor (NTC)
2- positive temperature coefficent thermistor (PTC)

PTC

A Thermistor whose resistance increases with the increase in temperature of thermistor is called positive temperature co-efficent thermistor (PTC).

NTC

A thermistor whose resistance decreases with the increase in temperature of thermistor is called negative temperature co-efficent thermistor.

Application/uses of Thermistor:

Thermistors are used:

1- As potential divider in electrical circuits.
2- As thermometer to measure the temperature of an object.
3- In electrical devices such as AC, refrigerators act as heat sensors.