Chapter – 4

DC circuit

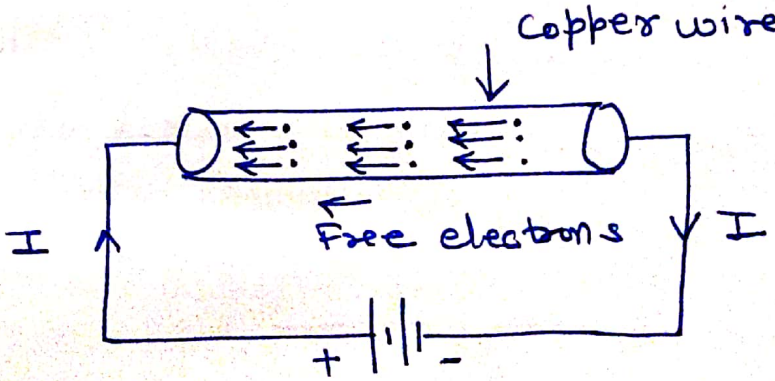
Current :– The rate of flow of charge carriers is called current. current is denoted by I.

Mathematically current is defined as the ratio of charge upon time.

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

Unit for current is Ampere or Coloumb/sec

Direction of current :– By convention, the direction of current is always opposite to the flow of electrons. Electrons flow from negative terminal to the pasitive terminal of the battery and current will flow from pasitive terminal to the negative terminal of the battery.

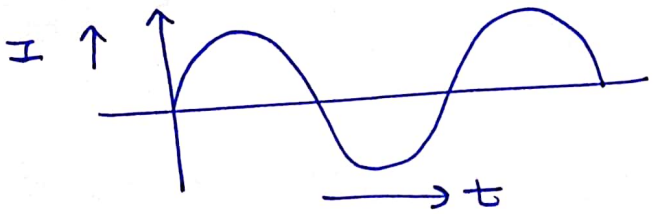


* The current which flows due to free electrons called electric current

* Charge is a scalar quantity.
* Current is a scalar quantity.

Ques :- What is the difference alternating current and direct current?

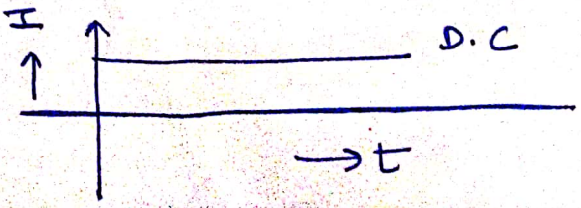
Ans :- Alternating current :- If the magnitude and direction of current changes continuously at regular interval of time, is called alternating current.



Alternating current (a.c)

Direct current (d.c) :- If the magnitude and direction of current remain same after regular interval of time, is called direct current.

Example :- Current from solar cell, battery, cell etc. D.C current is used in electronic Devices.



Ques:- Give difference between electro motive force (E.M.F) and Potential difference (P.D).

Ans

Electro - Motive force (E.M.F)	Potential Difference (P.D)
1. It is the difference of potential between two electrodes of a cell or battery in open circuit.	1. It is the difference of potential between two electrodes when the circuit is closed.
2. The term is strictly used for the source of supply. e.g → cell or Battery.	2. It exist throughout the circuit.
3. It does not depend upon the resistance of circuit.	3. It depends upon the resistance of circuit.
4. It can exist in an open circuit.	4. It can exist only when the circuit is closed.
5. It is alway greater than potential difference.	5. It is always less than E.M.F.
6. Unit for E.M.f is volt.	6. Unit for P.D is also volt.
7. E.M.f is the cause for Potential difference.	7. Potential difference is the effect of EMF.

Ques :- Define Resistance. What are the factors on which resistance of a material will depend?

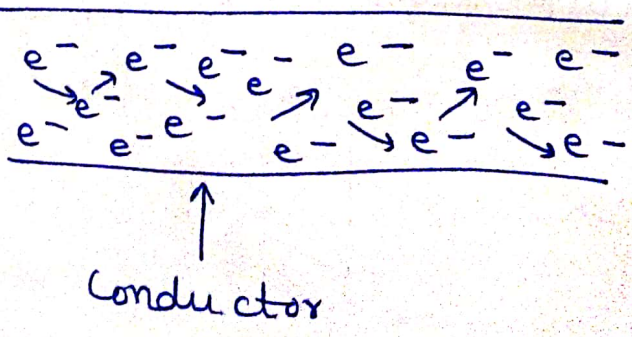
Ans :- Resistor :- Resistor is a device which ~~oppose~~ opposes the flow of electric current.

Resistance :- Resistance is the property of a material which opposes the flow of electric current. Resistance is denoted by 'R'.

Unit for Resistance :- 'ohm' is the unit for resistance.

Symbol for Resistance → 

Cause of Resistance :- In a conductor, there are large no. of free electrons. when these electrons are moving, they will collide with each other. Due to their collison, their is a loss in their kinetic energy which get converted into heat energy.



Factors on which resistance depend

Resistance of a conductor will depend on the following factor:-

1. **length** :- The resistance 'R' of a conductor is directly propotional to the length i-e

$$R \propto l \quad \text{--(1)}$$

2. **Area of cross-section(a)**:- The resistance of a conductor is inversely propotional to the area of cross-section. Because more is the area of cross-section, the electrons can move with less collison.

$$R \propto \frac{1}{a} \quad \text{--(2)}$$

3) **Nature of material** :- Different material offer different resistance due to their different atomic structure.

4 **Temperature** :- Resistance of conductor increase with increase in temperature as we increase the temperature, the K.E of electrons increase and they will collide more.

Now $R \propto \frac{l}{a}$, $R = \rho \frac{l}{a}$ where ρ → specific Resistance or Resistivity

Ques:- What do you mean by specific resistance? What are the factors on which specific resistance depends?

Ans Specific Resistance is also known as resistivity. It is denoted by ρ.

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

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

$$\rho = \frac{Ra}{l}, \quad \rho = R \text{ for } a = 1m^2, \; l = 1m$$

So specific resistance is equal to the resistance of material having length of 1m and area of cross-section of $1 m^2$.

Unit for resistivity :-

$$\rho = \frac{Ra}{l} = \frac{\text{ohm} - m^2}{m} = \boxed{\text{ohm} - m}$$

Factor on which Resistivity depend

Resistivity will only depend upon the nature of material. Means it does not depend upon length and area of material. It only depend upon the nature of material. Means ρ is different for copper, Silver, Aluminium etc

Ques :- Define Conductance and Conductivity.

Ans :- Conductance :- The reciprocal of resistance is called conductanee. It is denoted by 'G'. The property of a material which allow the current pass through it is called conductanee.

$$\text{Conductance } (G) = \frac{1}{R}$$

Unit for Conductance is $G = \frac{1}{\text{ohm}} = \text{ohm}^{-1}$ or mho

Conductivity :- The reciprocal of resistivity is called Conductivity. It is denoted by 'K'.

$$\text{Conductivity } (K) = \frac{1}{\rho}$$

Unit for Conductivity is

$$k = \frac{1}{\rho} = \frac{1}{\text{ohm-m}} = \text{ohm}^{-1}\,m^{-1}$$

or

$$\text{mho}\,m^{-1}$$

Ques :- What do you mean by Super Conductor?

Ans :- As we know that

$$\text{Conductance } (G) = \frac{1}{\text{Resistance}}$$

When the resistance of a conductor approaches to zero, then the conductance will approach to infinity.

$$G = \frac{1}{0} = \infty$$

So when the resistance of conductor approaches to zero, its conductance becomes infinity, are called Super conductor. The resistance of a conductor approaches to zero at a particular temperature is called critical temperature.

for eg. → Hg becomes superconductor below 4.2 K

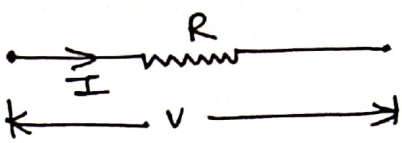
other examples → Lead, Tin becomes superconductor at a temperature of about 0.05 K.

Application :- Superconductors are used in making of supercomputers.

J

Ques :- What do you mean by ohm's law? Give Experimental verification for ohm's law.

Ans :- ohm's law :- Acc. to this law current flowing through a conductor is directly propotional to the potential difference applied across the ends of conductor provided the physical conditions like temperature, pressure remain same.



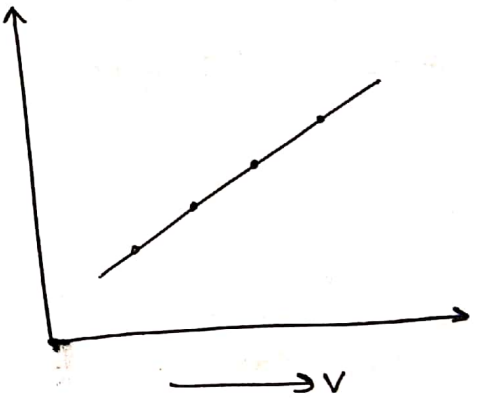
$$V \propto I$$

$V = IR$ where 'R' is constant called Resistance

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

Experimental verification

In experimental verification we take the readings of voltmeter and ammeter. Suppose at voltage V_1 current will be I_1, at voltage V_2 current will be I_2 and so on. After taking the no. of readings, we find the ratio of voltage and current.



$$\frac{V_1}{I_1} = \frac{V_2}{I_2} = \frac{V_3}{I_3} = \text{---} = \text{constant}$$

we get a straight line when we plot graph between voltage and current.

Hence ohm's law is verified.

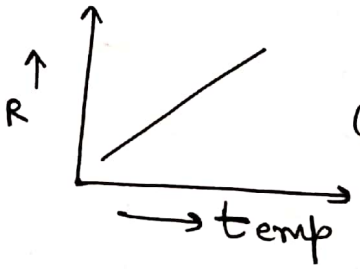
★ Conductor obey ohm's law are called Ohmic — conductors. for eg — Aluminium, Silver copper etc

★ Semi-conductors do not obey ohm's law are called non-ohmic conductors. for eg → Silicon, Germanium etc.

Ques :- What is the effect of temperature on Resistance ?

Ans :- The resistance of a material changes with change in temperature :-

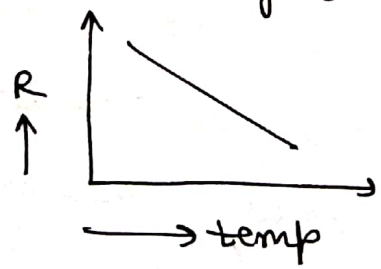
(1) for pure metals (Conductors) :- The resistance of all pure metals (e.g → copper, silver) increases with increase in temperature.



(for pure metals)

(2) For Semi-conductors :-

For semi-conductors, their resistance decreases with increase in temperature. for eg → Silicon, Germanium

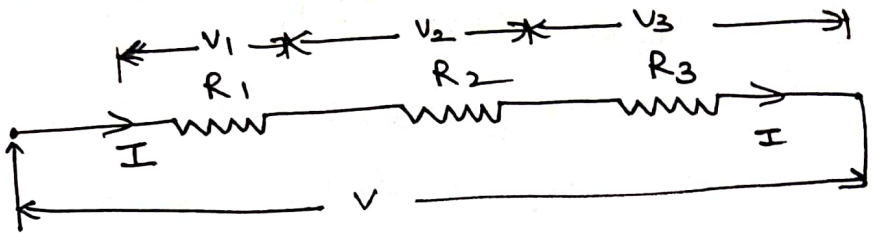


3. For Insulators :- for Insulators, the resistance decreases with increase in temperature, but decrease in resistance is not so much. for eg. in wood, glass, rubber etc.

Ques :- Derive an experession for resistance in series and in parallel.

Ans Resistance In series

Let's consider three resistance are connected in series.



In series the current will remain same but voltage get divided across each resistance.

Now $V = V_1 + V_2 + V_3$ — (1)

but $V = IR$

$V_1 = IR_1$

$V_2 = IR_2$

$V_3 = IR_3$

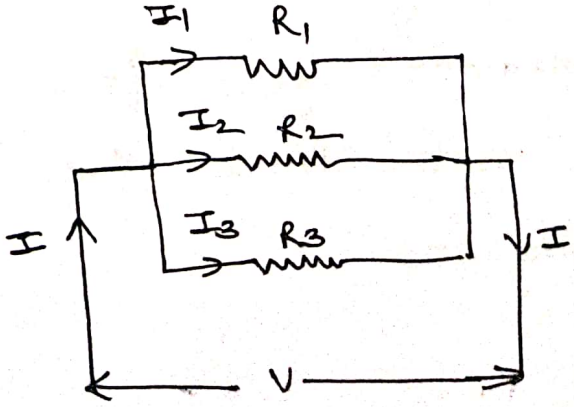
Put in eqn (1)

$$IR = IR_1 + IR_2 + IR_3$$

$$\boxed{R_S = R_1 + R_2 + R_3}$$

Resistance In parallel

Let us consider three resistances are connected in parallel.



In parallel, the voltage will remain same but current get divided across each resistances.

so $I = I_1 + I_2 + I_3$ —①

But $V = IR$, $I = \frac{V}{R}$

$V_1 = I_1 R_1$, $I_1 = \frac{V}{R_1}$

$V_2 = I_2 R_2$, $I_2 = \frac{V}{R_2}$

$V_3 = I_3 R_3$, $I_3 = \frac{V}{R_3}$

Put in ①

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\boxed{\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

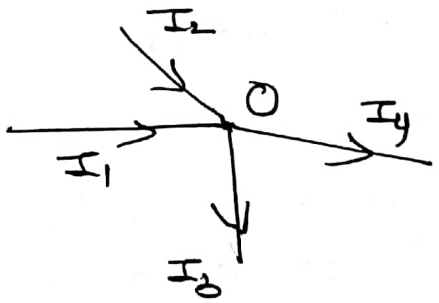
★ Application of Parallel Circuit

The appliances are connected in parallel as they work Independently. If one of the appliances get fail due to some fault, it will not effect the working of other appliances.

Ques :- Discuss Kirchoff's law.

Ans :- Kirchoff's law are used in solving circuit which can not be easily solved by ohm's law.

First law :- The algebraic sum of all the current meeting at any junction point in an electric circuit is zero.



$$I_1 + I_2 = I_3 + I_4$$

Amount of current Entering = Amount of current leave

or $I_1 + I_2 + (-I_3) + (-I_4) = 0$

IInd law :- In any closed circuit, the Sum of voltage drop and the E.M.F of the circuit is zero.

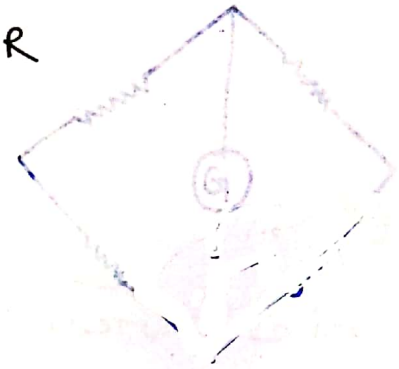
$$EMF + \text{Voltage drop} = 0$$

or

$$EMF + IR = 0$$

Ques Give construction and working of wheat stone bridge.

Ans:- Wheat stone bridge was given by Wheat-stone. It is used to find the value of Unknown resistance. It consist four resistances P, Q, R and X.



P, Q are fixed resistances.

R → Varriable resistance

X → Unknown resistance.

A Galvanometer is connected between B and D. That's why it is called bridge because galvanometer will act as a bridge.

Principle of wheat stone bridge:- A wheat stone bridge is said to be balanced when galwometer will show no deflection. which means no current will flow through galvanometer. This will happen only when potential at point B and D are same.

Working:- Consider a closed circuit ABDA.

Acc. to Kirchoff's second law

$$I_1 P + I_g G_1 - (I - I_1) R = 0 \quad \text{(1)}$$

Similarly in closed circuit BCDB

$$(I_1 - I_g) Q - (I_g + I - I_1) X - I_g G_1 = 0 \quad \text{(2)}$$

whe

Now when the bridge is balanced

$$\boxed{I_g = 0}$$

Put in eqn (1) & (2)

$$I_1P + I_gG - (I - I_1)R = 0$$

Put $I_g = 0$

$$I_1P + 0 - (I - I_1)R = 0$$

$$\boxed{I_1P = (I - I_1)R} \quad -(3)$$

Now Put $I_g = 0$ in eqn no. (2)

$$(I_1 - I_g)Q - (I_g + I - I_1)X - I_gG = 0$$

$$(I_1 - 0)Q - (0 + I - I_1)X - 0 = 0$$

$$I_1Q - (I - I_1)X = 0$$

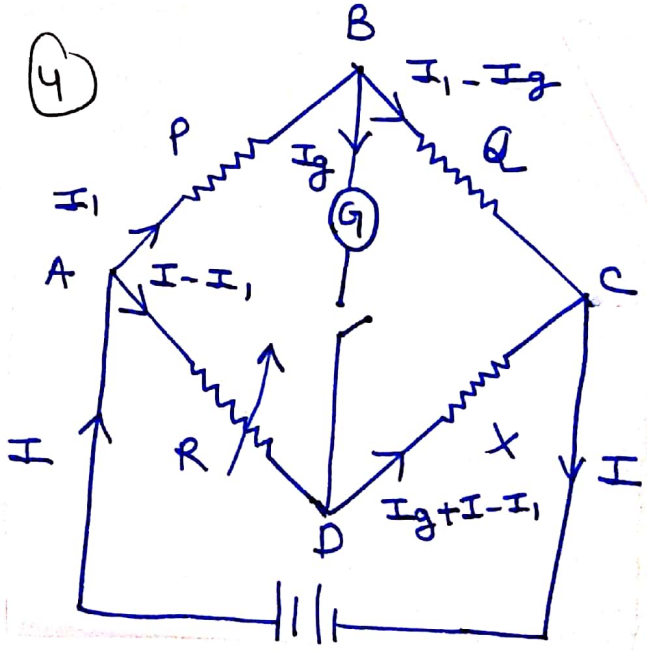
$$\boxed{I_1Q = (I - I_1)X} \quad -(4)$$

Divide eqn (3) with (4)

$$\frac{I_1P}{I_1Q} = \frac{(I - I_1)R}{(I - I_1)X}$$

$$\boxed{\frac{P}{Q} = \frac{R}{X}}$$

$$\boxed{X = \frac{Q \cdot R}{P}}$$



This is how we are able to find the value of unknown resistance.

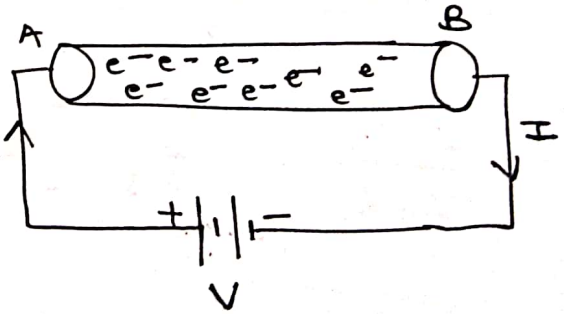
* Slide wire bridge is one of the application of wheat stone bridge. It is used to find the value of unknown Resistance.

Ques :- What is cause of heating effect of current or Joule's heating effect? Explain.

Ans :- Whenever current is flowing through a, it produces heat in the conductor. The effect is called heating effect of current. This effect is called Joule's heating effect.

Cause of heating :- As we know that when the current is flowing, it flow due to moving electrons. As the electons are moving, they collide with each other. Due to their collison, their is a loss of Kinetic Energy. And the losed Kinetic Energy get converted into heat Energy.

Let us consider a conductor AB. Let 'I' current be flowing through the conductor when potential 'V' is applied in time 't'.



As we know

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

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

$$\boxed{q = It} \quad -(1)$$

Also we know that

$$V = \frac{W}{q}$$

$$\boxed{W = Vq} \quad -(2)$$

where 'W' is the work done in moving the charge 'q' from A to B

But $q = It$ from eqn (1)

Put in (2)

$$\boxed{W = VIt}$$

Work is a form of Energy. So this work will be stored in the form of Heat Energy

So $H = W = VIt$

$$\boxed{H = VIt} \quad -$$

but $V = IR$

So $H = IR(It) = I^2Rt$

So $\boxed{H = I^2Rt}$

Ques :- Define Electric Power.

Ans The rate of doing work is called Electric Power.

$$\text{Power} = \frac{\text{Work}}{\text{time}}$$

The electric Power is also given as product of voltage and current.

$$\boxed{P = VI}$$

Unit for Electric Power :-

S.I unit → Watt

As Power $= VI$ — (1)

but $V = IR$ Put in (1)

So $\boxed{P = I^2R}$

So $\boxed{P = VI = I^2R = \frac{V^2}{R}}$

Ques :- Define concept of Electric Energy.

Ans Electric Energy → The ability to do work is called Electric Energy.

Mathematically Electric Energy is given as the product of Power and time.

E = Power x time

$E = Pt$ —(1)

But $P = VI$

so $E = VIt$

or $V = IR$

$E = I^2Rt$

Unit for Energy → Joule

1KWh → One Kilo watt hour is also the unit for Electrical Energy.

$1KWh = 3.6 \times 10^6$ Joule

One B.O.T = 1KWh

where B.O.T means Board of Trade unit

Ques :- What are the application of D.C. Circuit in various electronic Devices?

Ans :- (1) DC circuit are used in CRO (Cathode Ray Oscilloscope) to controll the movement of electrons in the tube.

(2) In televisions sets filter circuits are used to safe the television in rainy season are, make use of DC circuit.

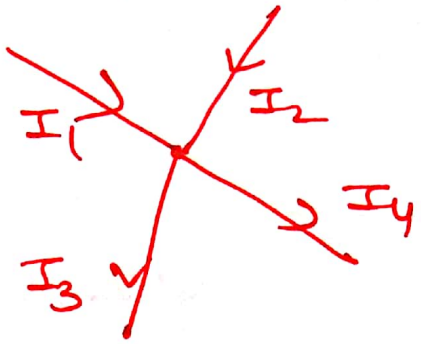
(3) In computer, D.C circuit are used.

(4) All audio – video system make use of DC circuit.

Kirchoff's laws (To solve complicated circuit not solved by ohm's law)

First law

$I_1 + I_2 = I_3 + I_4$



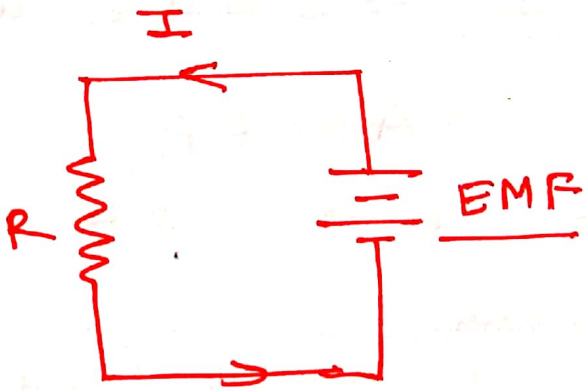
or

$I_1 + I_2 + (-I_3) + (-I_4) = 0$

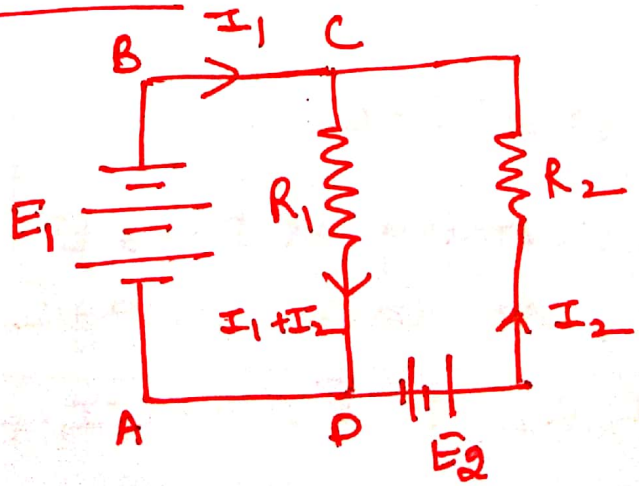
IInd law

Sum of EMF + Voltage drop = 0

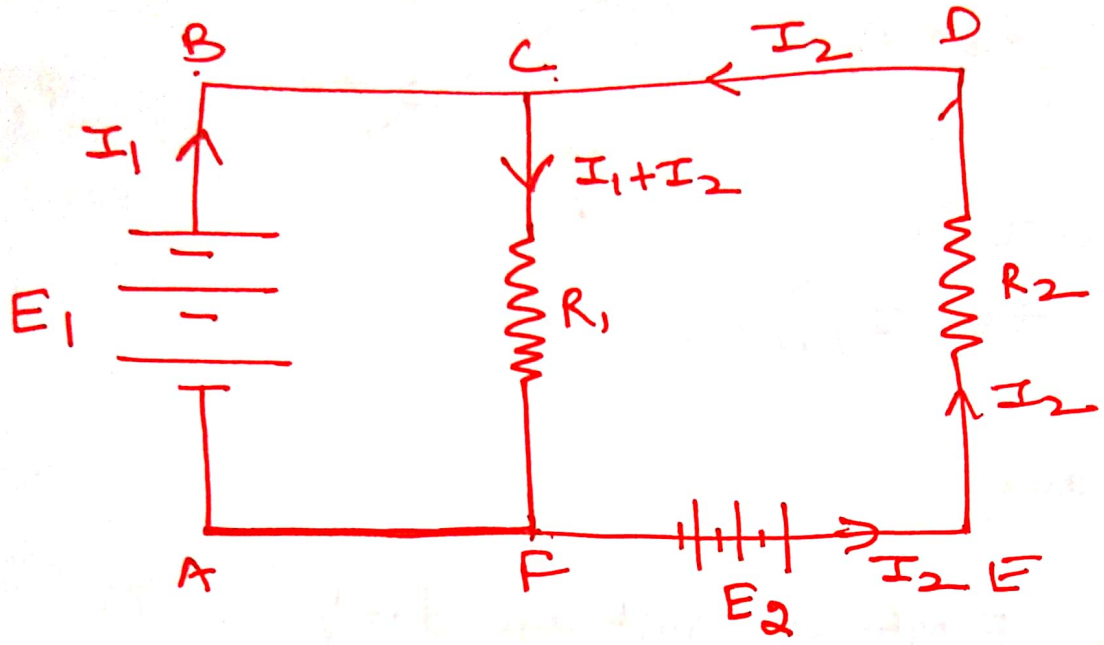
EMF + IR = 0



Sign conventions



Sign Conventions.



Step 1 → choose a closed ckt

ABCFA

A → B → C → F → A

As we

$$-E_1 + (I_1+I_2)R_1 = 0$$

CDEFC

we are coming as D → E but 'I' flow E to D, so take voltage drop (-ve)

$$-I_2R_2 + E_2 - (I_1+I_2)R_1 = 0$$

As we go from E to F, battery +ve terminal came.

Wheat stone Bridge

(1) To find unknown resistance.

(2) It is called bridge because galvanometer act as bridge.

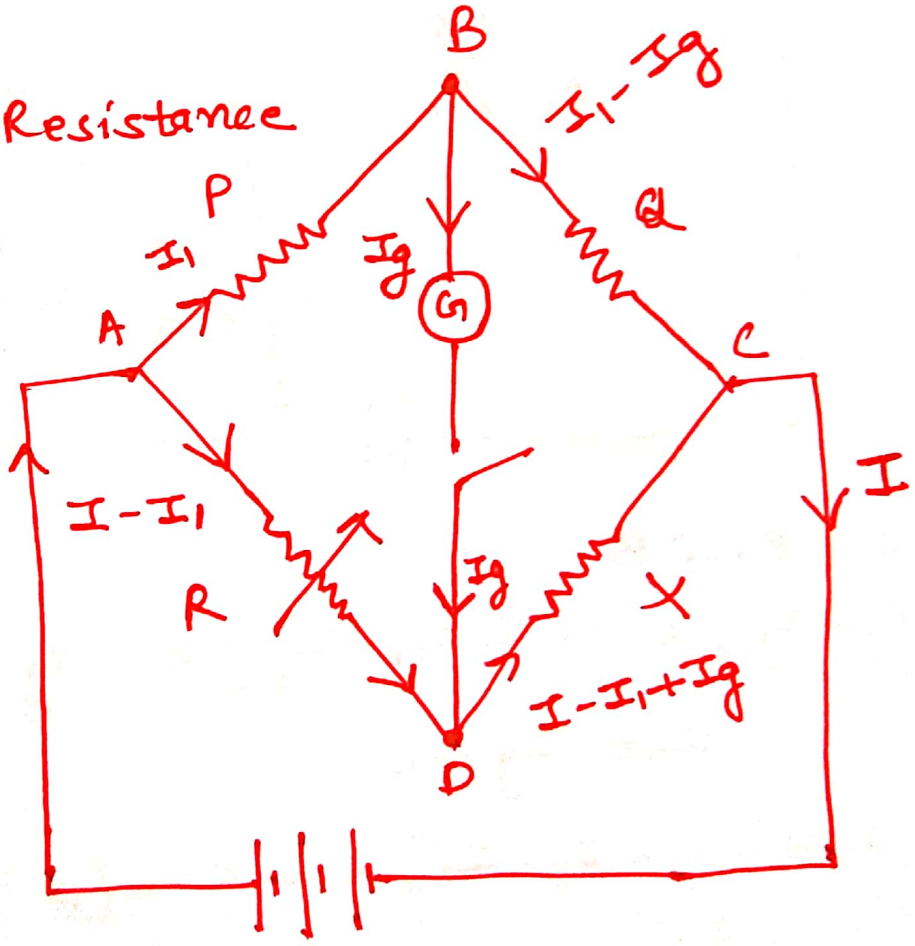
(3) Principle :- A bridge is said to be balanced when ~~no~~ ~~current~~ galvanometer show no deflection i.e $I_g = 0$. This will happen when potential at 'B' and 'D' is same.

P, Q, R, X → four Resistance

R → Vaoriable R

X → unknown resistance

I



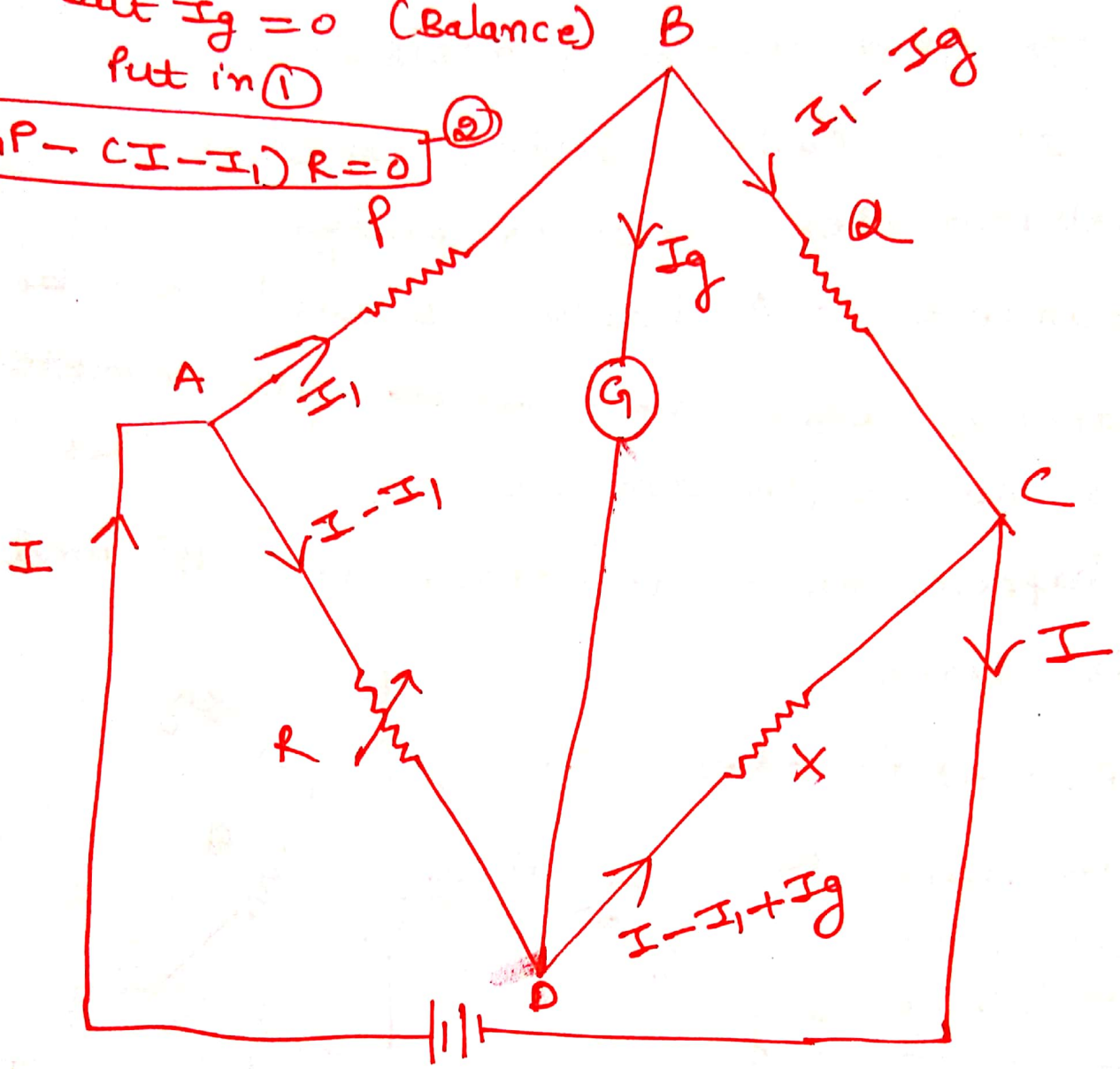
In ABDA

$I_1P + I_g G - (I - I_1)R = 0$ — (1)

but $I_g = 0$ (Balance)

Put in (1)

$I_1P - (I - I_1)R = 0$ — (2)



In BCDB

$(I_1 - I_g)Q - (I - I_1 + I_g)X - I_g G = 0$

but $I_g = 0$

$I_1 Q - (I - I_1)X = 0$ — (3)

or

$I_1 Q = (I - I_1)X$ — (3)

from (2)

$I_1 P = (I - I_1)R$ — (4)

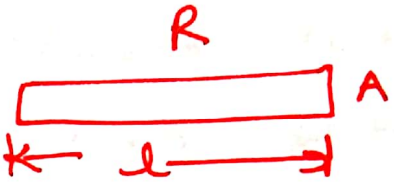
Divide (4) by (3)

$$\frac{P}{Q} = \frac{R}{X}$$

Numericals :- A given piece of wire of length l, cross-sectional area A and resistance R is stretched uniformly to a wire of length $2l$. What is new resistance ?

Ans :-

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



$$R' = \rho' \frac{(2l)}{A/2}$$

$$R' = 4 \frac{\rho l}{A}$$

So $R' = 4R$

Num :- Length of a wire is halved, what will be conductance

Ans

$$G = \frac{1}{R}$$

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

$$\text{So} \quad G = \frac{A}{\rho l}$$

as $G \propto \frac{1}{l}$, so if $l = \frac{1}{2}$, 'G' becomes double

Ques :- Three resistors of 20Ω, 15Ω and 15Ω are connected in series and a voltage of 100V is applied to the combination. Calculate

(a) Total resistance (b) current

(c) Voltage drop across each resistance

Chapter 4

Formula

1. $Q = ne$

$Q \rightarrow$ Total charge

$n \rightarrow$ no. of electons

$e \rightarrow$ charge of an electon $= 1.6 \times 10^{-19} C$

2. $I = \frac{q}{t}$

(3) $R = \frac{\rho l}{a}$

(4) Specific Resistance of or resistivity does not have any formula. It only depend upon the nature of material.

(5) Conductance $(G) = \frac{1}{R}$

(6) $R_s = R_1 + R_2 + R_3$

(7) $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

(8) $V = IR$

(9) Heat Energy $(H) = I^2Rt$

(10) Power $= VI$

(11) Electric Energy $= VIt$