Electrical Measurement

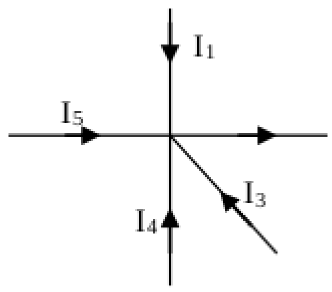
Kirchoff's law

- **First law:**

  In an electric circuit, the algebraic sum of currents at any junction point is zero. i.e.$\sum I = 0$ e.g. in figure a poinr A:

  $$I_1 + I_5 + I_4 + I_3 - I_2 = 0$$

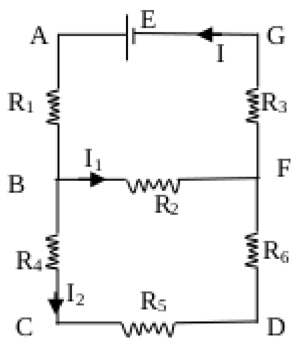
  In this law the current flowing towards the points are taken +ve sign while the current flowing away from the point are taken −ve sign.



  This law is based on law of conservation of charge.

- **Second Law:**

  In a closed circuit the algebraic sum of products of current and resistance is equal to the total emf in the circuit i.e. $\sum E = \sum IR$. This law is based on the law of conservation of energy.



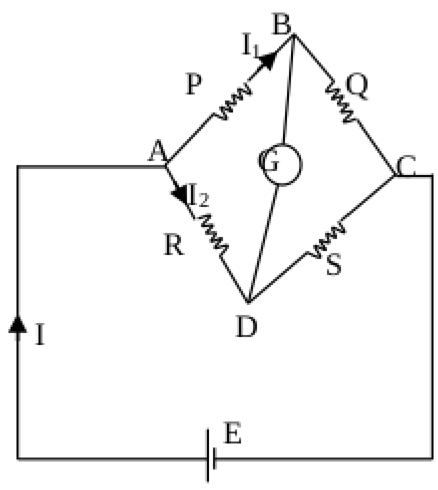
  In the circuit, in mesh BCDFB:

  $$I_2R_4 + I_2I_5 + I_2R_6 - I_1R_2 = 0$$

  Or, $I_2R_4 + I_2I_5 + I_2R_6 = I_1R_2$

  The Kirchhoff's first law is applied at the junction so, called junction law & second law is used at loop (mesh) so called loop law.

Wheatstone's Bridge Network



The Wheatstone's bridge is shown in figure P, Q, R and S are four resistances and E is a battery. The Wheatstone's bridge is said to be balanced when no current flows in galvanometer i.e. when potential of B = potential of D.

This condition of balanced Wheatstone's bridge is achieved, when

$$\frac{P}{Q}=\frac{R}{S} \Rightarrow QR=PS$$

Meter Bridge

Meter bridge works on the principle of Wheatstone's bridge and is used to determine the unknown resistance.

$$S=\frac{R(100-l)}{l}$$

where,

$S=$ unknown resistance

$R=$ known resistance

$l=$ balancing length

The bridge become most sensitive when all four resistors are of same order.

Potentiometer

A potentiometer generally consists of uniform wire of length 10m stretched on a wooden board between two thick copper strips. Each wire is 100 cm long. A meter scale is fitted parallel to its length. A steady current is set up in the wire by means of a battery. This maintains the uniform potential gradient along the length of wire.

i. Potential gradient,

$$\left(\frac{dV}{dl}\right)=\frac{V_A-V_B}{l}=\frac{P.D.}{\text{length of wire}}$$

ii. Comparison of emf,

$$\frac{E_1}{E_2}=\frac{I_1}{I_2}$$

iii. Internal resistance,

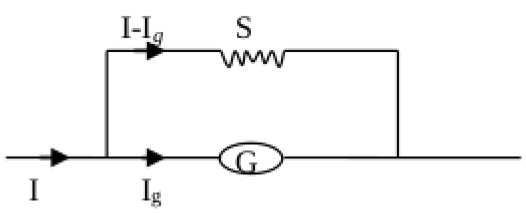
$$r=\left(\frac{l_1}{l_2}-1\right)R$$

where,

$R \rightarrow$ known resistance
$I_1 \rightarrow$ balance length for emf
$l_2 \rightarrow$ balance length for terminal p.d

Conversion of galvanometer into ammeter

A galvanometer of resistance G and full scale deflection current I_g converted into an ammeter of range O -I by shunting it with resistance S.



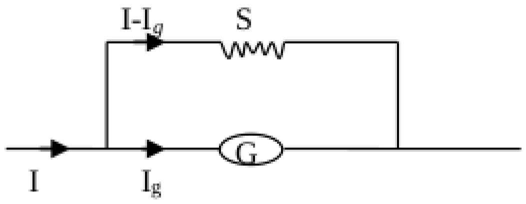
$$S=\frac{I_a}{I-I_g}G=\frac{G}{\left(\frac{I}{I_g}-1\right)}=\frac{G}{n-1}$$

where $n=\dfrac{I}{I_g}$

Total resistance of ammeter $(G')=\dfrac{SG}{S+G}$

Conversion of galvanometer into voltmeter

A galvanometer of resistance G and full scale deflection current I_g is converted into a voltmeter of range 0 -V by connecting a resistance R in series.



$$R = \frac{V}{I_g} - G$$

Total resistance of voltmeter $= R + G$