B.Sc. Part-2 Physics (Hons) Paper-iv, Lecture-16 on the topic

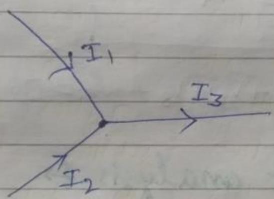
"Kirchhoff's Laws and Mesh Current Analysis."

Dr. Mohammad Aslam, Dept. of Physics
B.Sc. Part-2, Physics(Hons), Paper-IVth
Lecture-16

* Kirchhoff's Laws :->

(1) Kirchhoff's current law :->

Kirchhoff's current law states that current flowing into a node or a junction must be equal to current flowing out of it.
This is a consequence of charge conservation.



The current in the three wires must be related by:

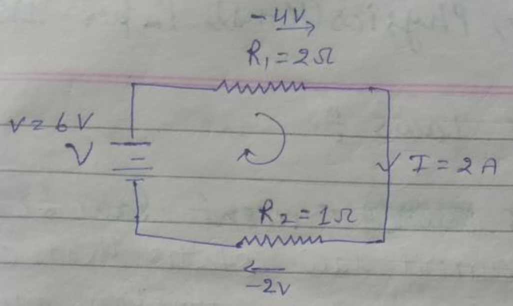
$$\boxed{I_1 + I_2 = I_3}$$

It is important to note that the current flowing towards the junction are taken to be positive, and the current flowing away from the junction is taken negative.
i.e

$$\boxed{I_1 + I_2 + (-I_3) = 0}$$

(2) Kirchhoff's voltage law :->

Kirchhoff's voltage law states that the sum of voltages around any closed loop in a circuit must be equal to zero.
This is a consequence of energy conservation.



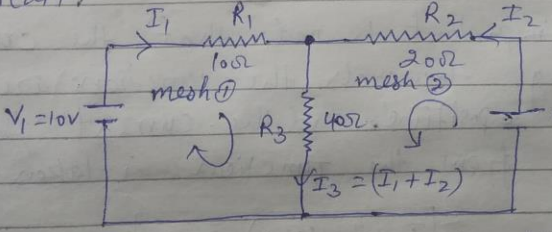
In any loop containing any number of components Kirchhoff's voltage law can be written as

$$\boxed{\sum_{K=1}^{n} V_K = 0}$$

i.e $\quad V_1 + V_2 + V_3 + \cdots = 0$

Mesh current analysis :-

mesh current analysis is a technique used to find the current circulating around a loop or mesh with in any closed path of a circuit.



To analyse the circuit using Kirchhoff's current law equations to determine the current I_1 and I_2 flowing in the two resistors.

apply Kirchhoff's voltage law in mesh ①

$$V_1 = I_1 R_1 + I_3 R_3$$

$$V_1 = I_1 R_1 + (I_1 + I_2) R_3$$

$$V_1 = I_1R_1 + I_1R_3 + I_2R_3$$

$$V_1 = I_1(R_1+R_3) + I_2R_3 \quad \text{—— (1)}$$

In mesh 2

$$V_2 = I_2R_2 + I_3R_3$$

$$V_2 = I_2R_2 + (I_1+I_2)R_3$$

$$V_2 = I_2R_2 + I_1R_3 + I_2R_3$$

$$V_2 = I_1R_3 + I_2(R_2+R_3) \quad \text{—— (II)}$$

Now multiply by R_3 in equation 1 and multiply by (R_1+R_3) in equation II and substract them

$$V_1R_3 = \cancel{I_1R_3(R_1+R_3)} + I_2R_3^2$$

$$V_2(R_1+R_3) = \cancel{I_1R_3(R_1+R_3)} + I_2(R_2+R_3)(R_1+R_3)$$

$$V_1R_3 - V_2(R_1+R_3) = I_2\left[R_3^2 - (R_2+R_3)(R_1+R_3)\right]$$

$$\boxed{I_2 = \frac{V_1R_3 - V_2(R_1+R_3)}{\left[R_3^2 - (R_2+R_3)(R_1+R_3)\right]}}$$

Now for I_1

$$V_1 = I_1(R_1+R_3) + I_2R_3$$

$$I_1 = \frac{V_1 - I_2R_3}{(R_1+R_3)}$$

$$I_1 = \frac{V_1}{(R_1+R_3)} - \frac{I_2R_3}{(R_1+R_3)}$$

$$I_1 = \frac{V_1}{R_1+R_3} - \frac{V_1R_3 - V_2(R_1+R_3)}{\left[R_3^2 - (R_1+R_3)(R_2+R_3)\right]} \times \frac{R_3}{(R_1+R_3)}$$

$$\boxed{I_1 = \frac{V_1}{(R_1+R_3)} - \frac{V_1R_3^2 - V_2R_3(R_1+R_3)}{R_3^2(R_1+R_3) - (R_1+R_3)^2(R_2+R_3)}}$$

and

$$\boxed{I_3 = I_1 + I_2}$$

put the values of V_1, V_2, R_1, R_2 and R_3 we can find the values of I_1, I_2 and I_3.