NOTES – CLASS 1

Network Terminology:

1. **Electrical Network:**
   An interconnection of electrical elements is defined as an electrical network.

2. **Electrical Circuit:**
   An electrical network with at least one source and a sink and having a closed path for current flow.
   Note: All electrical circuits are networks. But the converse need not be true.

3. **Active Element:**
   An element which supplies or delivers energy in an electrical network is called an active element. For example, Voltage Sources & Current Sources are active elements.

4. **Passive Element:**
   An element which absorbs or stores energy in an electrical network is called a passive element. For example, Resistors, Inductors & Capacitors.
   Note: Resistors dissipate the energy absorbed as heat. Inductors store the absorbed energy in their magnetic field whereas the capacitors store the energy in their electric field.

Basic Definitions:

1. Electric Current:

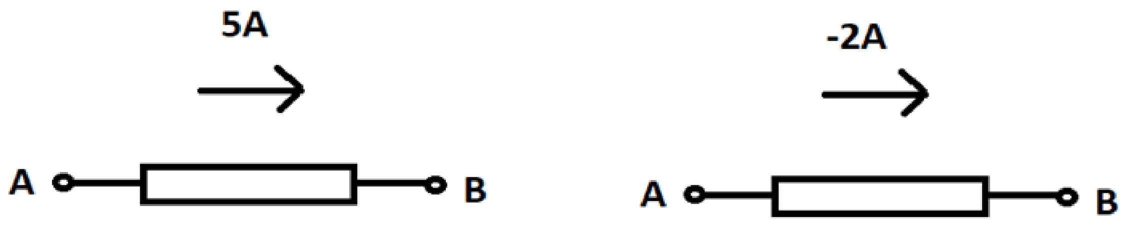
The rate of flow of charges across the cross section of a conductor is defined as the electric current.

It is given by the following equation

$$I = \frac{Q}{t} \text{ (or) } i = \frac{dq}{dt}$$

It is measured in Amperes (A) & 1 Ampere = 1 Coulomb/sec

An electric current is characterized by its magnitude and direction. The direction is conventionally represented in the direction of flow of positive charges even though actually electrons cause current in conductors.



(a) (b)

In figure (a) above, a current of 5A flows from terminal A to terminal B. In figure (b), a negative current is shown. A negative current is one which flows opposite to the direction marked. Hence, in figure (b), a current of 2A flows from terminal B to terminal A.

2. Potential Difference:

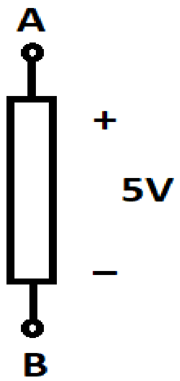
The energy required to move unit positive charge from one terminal to another is defined as the potential difference between the terminals.

It is given by the following equation:

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

It is also termed as voltage. It is measured in Volts (V) & 1 Volt = 1 Joule/Coulomb

An electric voltage is characterized by its magnitude and polarity.

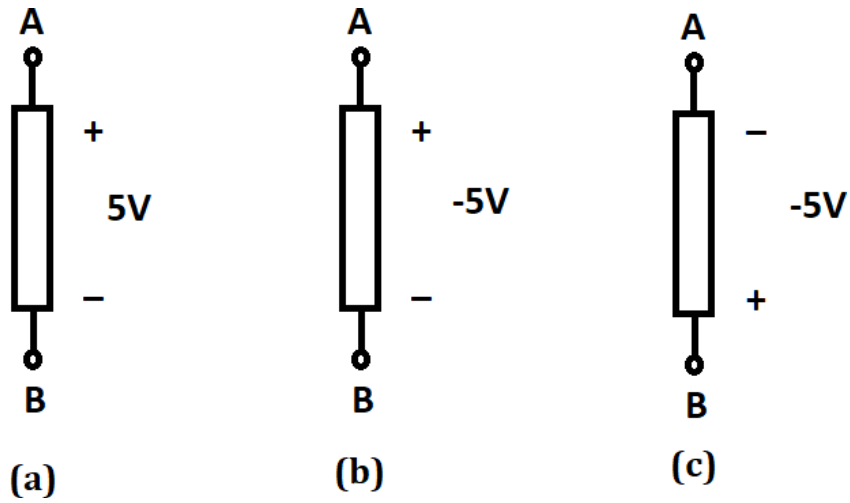


In the figure above, potential difference between A & B is 5V. Here, terminal A is higher in potential with respect to terminal B.

Double Subscript Notation for Voltage:

Since an electric voltage is defined between two terminals, it is represented by double subscript notation.

V_{AB} means relative potential of terminal A with respect to terminal B. If terminal A is higher in potential with respect to terminal B, then V_{AB} is positive. Otherwise, it is negative.



In figure (a) above, terminal A is 5V higher in potential than terminal

B. Hence, V_{AB} = 5V in this case.

In figure (b) above, terminal A is -5V higher in potential than terminal B which means that actually terminal B is higher in potential than terminal A. Hence, V_{AB} = -5V in this case.

In figure (c) above, terminal A is marked with a negative sign. Hence, it is -5V lower in potential than terminal B which means that actually terminal A is +5V higher in potential than terminal B. Hence, V_{AB} = 5V in this case.

Also, $V_{BA} = -V_{AB}$.

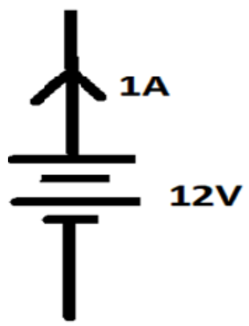
3. Electric Power:

The rate of absorption or delivery of Electrical energy is called Electrical Power.

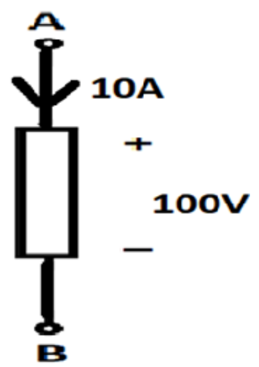
It is denoted by P and is given by the following equation: P = V*I

It is measured in Watts (W) & 1 Watt = (1 Volt)*(1 Ampere)

Conventionally, power absorbed is represented as positive & power delivered is represented as negative.



(a)



(b)

In figure (a) above, a battery delivers a power of (12V*1A) = 12W. Since it is power delivered, it is represented as -12W

In figure (b) above, a passive element such as a resistor is absorbing a power of (100V*10A) = 1000W. Since it is power absorbed, it is represented as +1000W.

Ohm's Law:

At a constant temperature, the potential difference across the terminals of a conductor is directly proportional to the current flowing through it.

i.e., V is proportional to I

Hence**, V = R*I**

where, R is the constant of proportionality called electrical resistance of the conductor.

It is measured in Ohms (Ω) and 1 Ohm = 1 Volt/Ampere

Resistance of a conductor is the opposition offered to the flow of current through it.

It is represented as shown below:

It depends on the resistivity of the material & its dimensions.

i.e., R = $\frac{\rho l}{A}$

Where, ρ is the resistivity measured in Ohm-m

l & A are the length and cross sectional area of the conductor in m & m^2 respectively.

Reciprocal of resistance is called Conductance denoted by G and given by

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

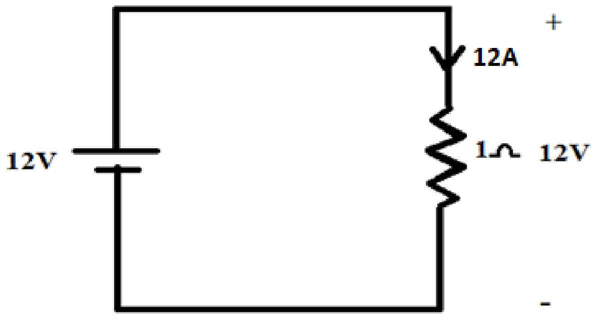
It is the ease with which a conductor allows the flow of current through it.

It is measured in Siemens (S).

Active & Passive sign conventions:

Active Sign Convention is applicable to active elements in an electric network. According to this, "current leaves positive terminal in an active element".

Passive Sign Convention is applicable to passive elements in an electric network. According to this, "current enter positive terminal in a passive element".



In the circuit shown above, 12V battery is an active element. It satisfies active sign convention i.e., current leaves positive terminal in 12V battery. 1Ω resistor is the passive element. It satisfies passive sign convention i.e., current enters positive terminal in 1Ω resistor.

Kirchhoff's Laws:

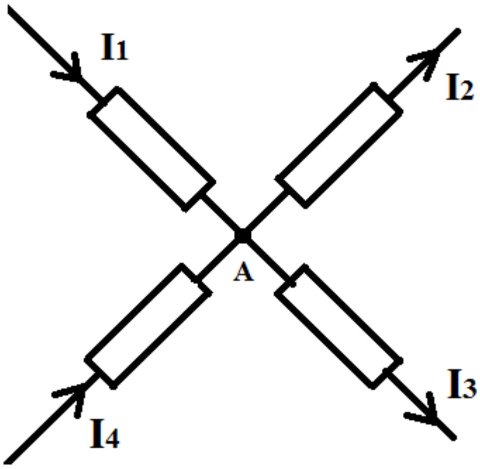
Kirchhoff's Current Law (KCL):

KCL States that

"At every node in an electric network, the algebraic sum of currents is Zero (or) sum of incoming currents is equal to the sum of outgoing currents".

A node is defined as the point of interconnection of two or more elements.

Consider the following example network:



By KCL at node A, $I_1 + I_4 =$

$I_2 + I_3$

KCL signifies the conservation of charge at every node in an electric network.

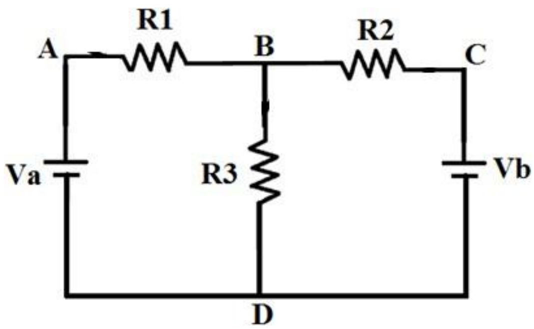
Kirchhoff's Voltage Law (KVL):

KVL States that

"Around every closed path in an electric network, the algebraic sum of voltages is Zero".

Any path which is traversed in an electric network, which starts and ends at the same point is defined as a closed path.

Consider the example network shown below:



ABDA, BCDB & ABCDA represent closed paths in this network.

While writing KVL, if one passes through an element from lower potential terminal to higher potential terminal, it is termed as 'Voltage Rise'. If an element is traversed from higher potential terminal to lower potential terminal, it is termed as 'Voltage Drop'.

Conventionally, Voltage drops are considered as negative and voltage rises as positive while writing KVL.

Hence, KVL in the path ABDA would be

$-V_1-V_3+V_a = 0$

Similarly, KVL in the path

BCDB is $V_2-V_b+V_3 = 0$

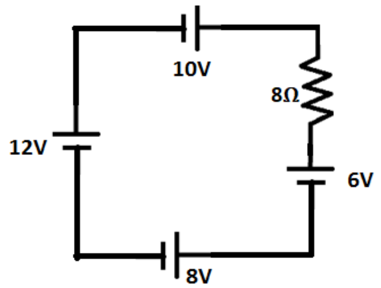
& KVL in the path ABCDA is

$-V_1+V_2-V_b +V_a = 0$

KVL signifies the conservation of energy around every closed path in an electric network.

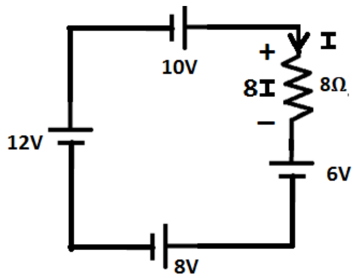
Numerical Examples on KVL:

Example 1: Find the current through 8Ω resistor in the network given.



Solution:

Let the current in the network be I.

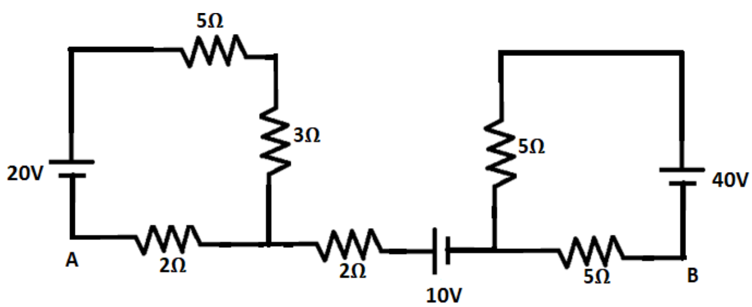


KVL around the path is

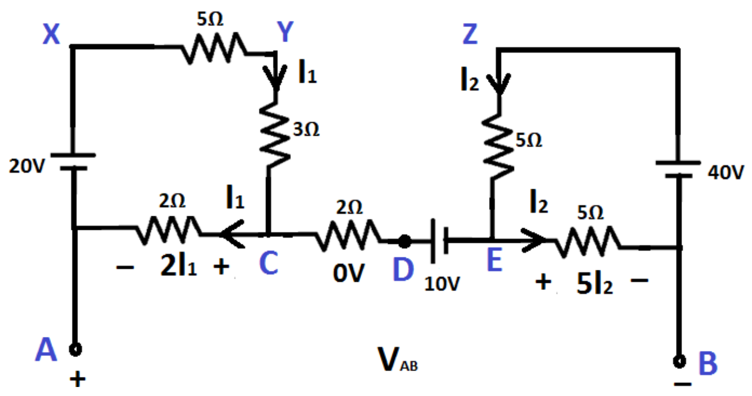
$$+10-8I-6-8+12 = 0$$

Hence, I = 1A

Example 2: Find the voltage V_{AB} in the network shown:



Solution:



KVL in the path AXYCA is

$$+20-5I_1-3I_1-2I_1 = 0$$

Hence, $I_1 = 2A$

KVL in the path BZEB is

$$+40-5I_2-5I_2 = 0$$

Hence, $I_2 = 4A$

KVL in the path ACDEBA is

$$+2I_1-10-5I_2+V_{AB} = 0$$

Substituting for I_1 & I_2 in the above equation, $V_{AB} = 26V$