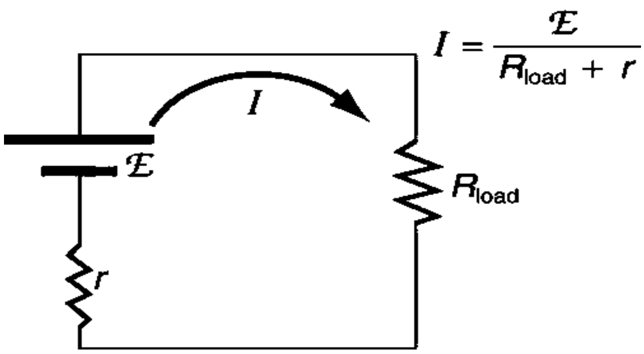
Cell and terminal voltage

A cell or an electrochemical cell is a device that is capable of obtaining electrical energy from chemical reactions or vice versa.

Internal resistance: The resistance offered by the electrolyte of a cell to the flow of current between its electrodes is called internal resistance of the cell.

Terminal P.D: The potential drop across the terminals of the cell when a current is drawn from it is called its terminal P.D



$\varepsilon = V + V'$

$\varepsilon = IR + Ir$

$\varepsilon = I(R+r)$

$I = \varepsilon / R + r$

Again

$V = \varepsilon - V'$

$V = \varepsilon - Ir$

Where v= terminal P.D

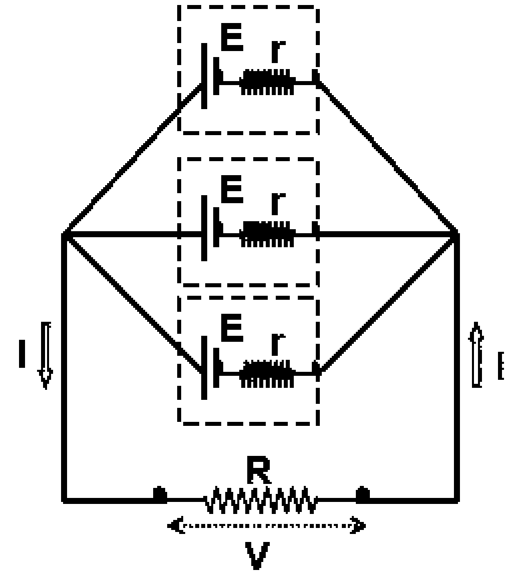
ε= EMF

r = internal resistance

Grouping of two cells in series and parallel

Cells in Parallel combination(When emf is same)

Cells are said to be connected in parallel when they are joined positive to positive and negative to negative such that current is divided between the cells.



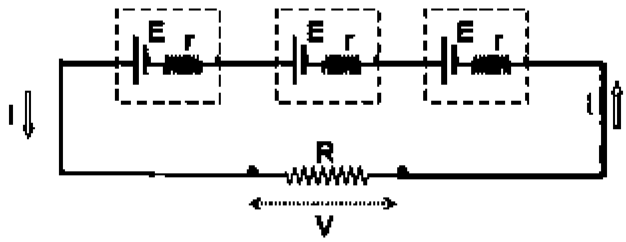
The emf of the battery is the same as that of a single cell.
The current in the external circuit is divided equally among the cells.
The reciprocal of the total internal resistance is the sum of the reciprocals of the individual internal resistances.
Total emf of the battery = E
Total Internal resistance of the battery = r / n
Total resistance of the circuit = (r / n) + R

$$\text{Current } I = \frac{nE}{nR + r}$$

(i) If $R \ll r/n$, then $I = n(E / r)$ (ii) If $r/n \ll R$, then $I = E / R$

<u>Cells in Series combination(When emf is same)</u>

When external resistance is negligible in comparison to the internal resistance, then the cells are connected in parallel to get maximum current.



Cells are connected in series when they are joined end to end so that the same quantity of electricity must flow through each cell.

1. The emf of the battery is the sum of the individual emfs
2. The current in each cell is the same and is identical with the current in the entire arrangement.
3. The total internal resistance of the battery is the sum of the individual internal resistances.

Total emf of the battery = nE (for n no. of identical cells)

Total Internal resistance of the battery = nr

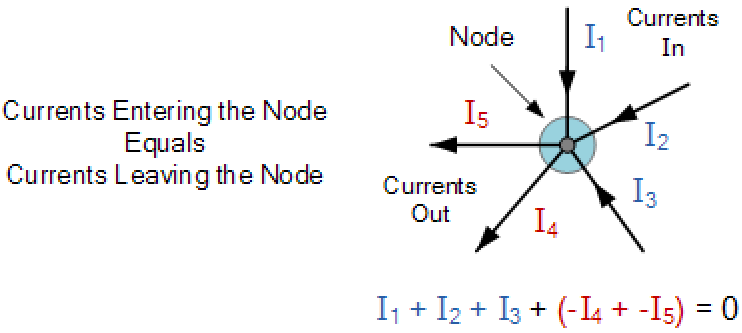
Total resistance of the circuit = nr + R

$$\text{Current } I = \frac{nE}{nr + R}$$

Kirchhoffs First Law – The Current Law, (KCL)

Kirchhoff's Current Law or KCL, states that the "*total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node*". In other words the algebraic sum of ALL the currents entering and leaving a node must be equal to zero, $I_{(exiting)} + I_{(entering)} = 0$. This idea by Kirchhoff is commonly known as the **Conservation of Charge**.

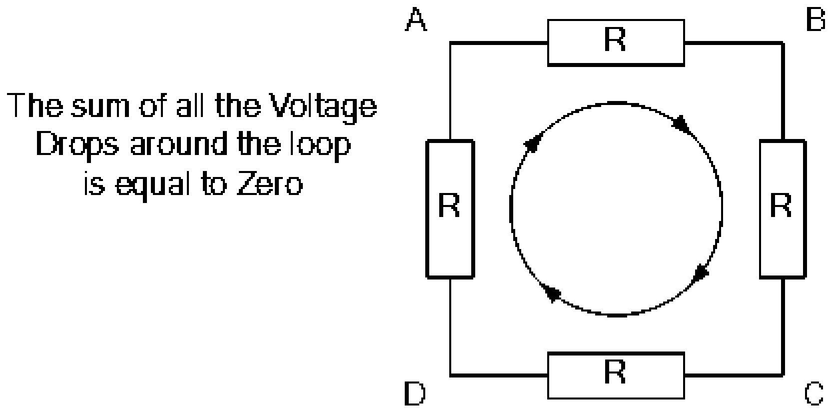
Kirchhoffs Current Law



Kirchhoffs Second Law – The Voltage Law, (KVL)

Kirchhoffs Voltage Law or KVL, states that "*in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop*" which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero. This idea by Kirchhoff is known as the **Conservation of Energy**.

Kirchhoffs Voltage Law



$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

Starting at any point in the loop continue in the **same direction** noting the direction of all the voltage drops, either positive or negative, and returning back to the same starting point. It is important to maintain the same direction either clockwise or anti-clockwise or the final voltage sum will not be equal to zero. We can use Kirchhoff's voltage law when analysing series circuits.