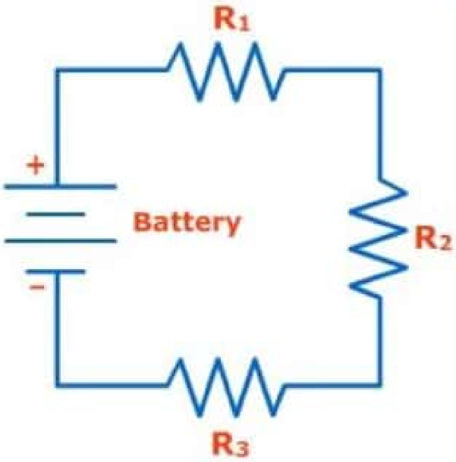
RESISTANCE

1 Resistance



The opposing effect to the flow of current is known as Resistance of the conductor. It is denoted by "R".

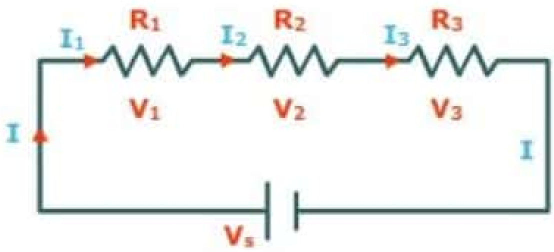
$$R = \frac{\rho l}{A}$$

ρ = Resistivity
l = Length
A = Area

Resistance (R) is measured in **Ohm** (Ω).

2 Combination

i Series



- The current passing through the individual resistance is same and its equal to magnitude of current that comes from the battery.

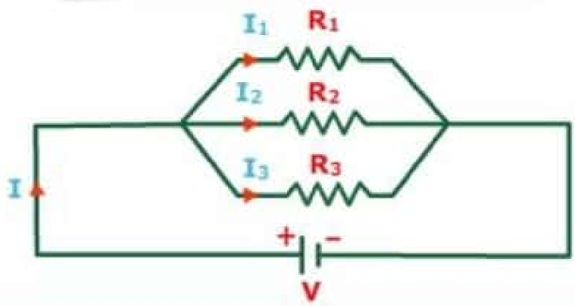
$$I = I_1 = I_2 = I_3$$

- The sum of the voltage across the individual resistance is equal to the voltage of the battery.

$$V = V_1 + V_2 + V_3$$

- $R_{eq} = R_1 + R_2 + R_3$
- The equivalent resistance of the circuit is always greater than the value of resistance in the circuit.

ii Parallel



- The sum of current passing through each resistance is equal to the total current coming from the battery.

$$I = I_1 + I_2 + I_3$$

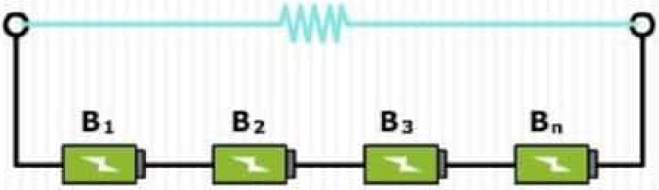
- The voltage across the individual resistance is same and is equal to the voltage of the battery.

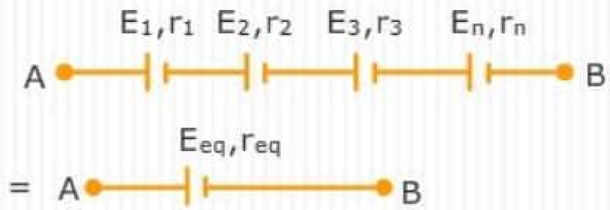
$$V = V_1 = V_2 = V_3$$

- $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- The equivalent resistance of the circuit is always less than the smallest value of resistance in the circuit.

GROUPING OF CELLS

1 CELLS IN SERIES





Equivalent EMF

$E_{eq} = E_1 + E_2 + \ldots\ldots + E_n$

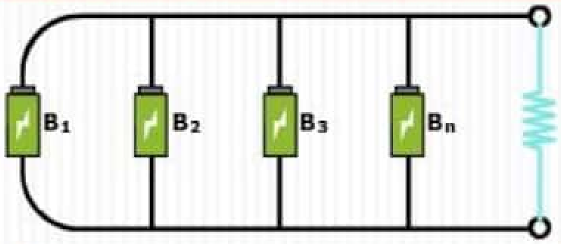
Equivalent internal resistance

$r_{eq} = r_1 + r_2 + r_3 + r_4 + \ldots\ldots r_n$

In n cells each of emf E are arranged in series and if r is internal resistance of each cell, then the total emf is equal to nE

and, current in the circuit, $I = \dfrac{nE}{R + nr}$

2 CELLS IN PARALLEL



$$E_{eq} = \frac{E_1/r_1 + E_2/E_2 + \ldots\ldots E_n/r_n}{1/r_1 + 1/r_2 + \ldots\ldots + 1/r_n}$$

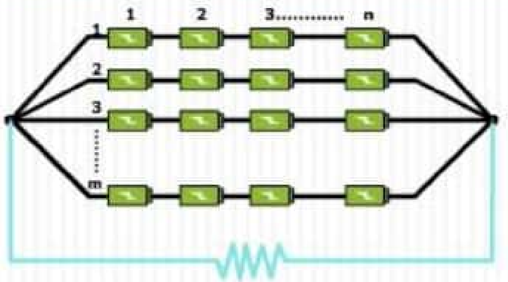
$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \ldots\ldots + \frac{1}{r_n}$$

If m cells, each of emf E and internal resistance r be connected in parallel and if this combination is connected to an external resistance (R) then the emf of the circuit $= E$.

internal resistance of the circuit $= \dfrac{r}{m}$

and $I = \dfrac{E}{R + \frac{r}{m}} = \dfrac{mE}{mR + r}$

3 CELLS IN MULTIPLE ARC



n = number of rows

m = number of cells in each row

Current $I = \dfrac{mE}{R + \frac{mr}{n}}$

for maximum current $nR = mr$

4 ELECTRICAL POWER

$$\text{Power, } P = \frac{V.dq}{dt} = VI = I^2 R = \frac{V^2}{R}$$

$$\text{Work, } W = VIt = I^2 Rt = \frac{V^2}{R} t$$

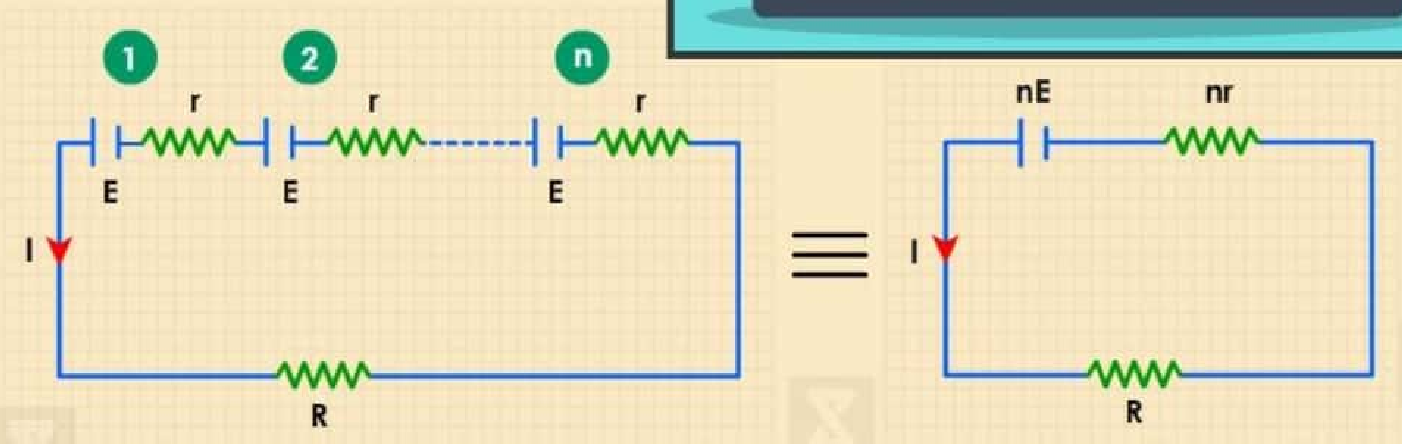
$$\text{Heat, } H = I^2 Rt \text{ Joule} = \frac{I^2Rt}{4.2} \text{ calorie}$$

Part I

CELLS AND ELECTRIC POWER

COMBINATIONS OF CELLS

1 CELL IN SERIES



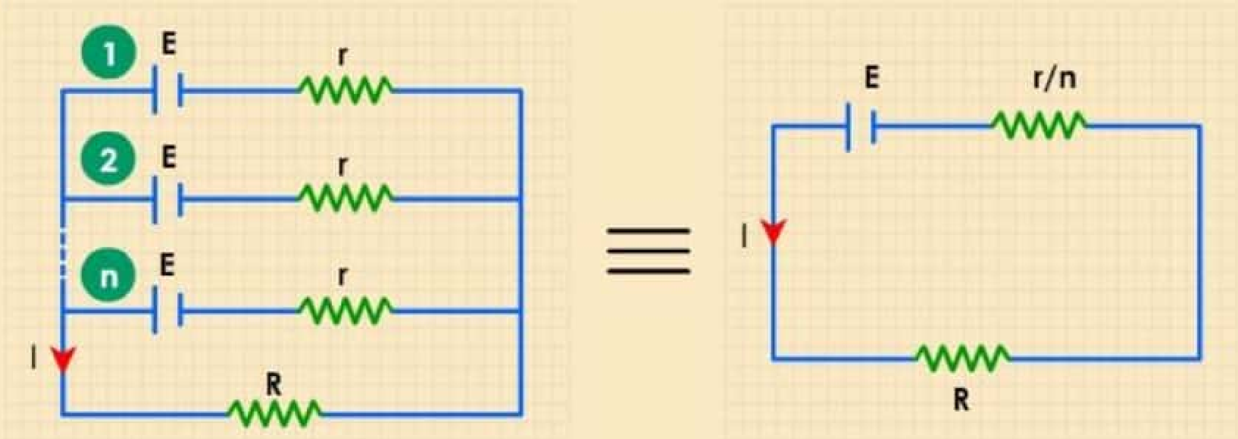
- Net EMF of the cells = nE,
- Total internal resistance = nr,
- Hence total resistance of the circuit = nr + R,

$$I = \frac{\text{net EMF}}{\text{Total Resistance}} = \frac{nE}{nr + R}$$

Case I If nr < < R, then I ≅ n E/R i.e. current obtained from the cells is approximately equal to n times the current obtained from a single cell.

Case II If nr > > R, then I ≅ nE/nr = E/r i.e. current obtained from the combination of n cells is nearly the same as obtained from a single cell.

2 CELL IN PARALLEL



When E.M.F's and internal resistance of all the cells are equal

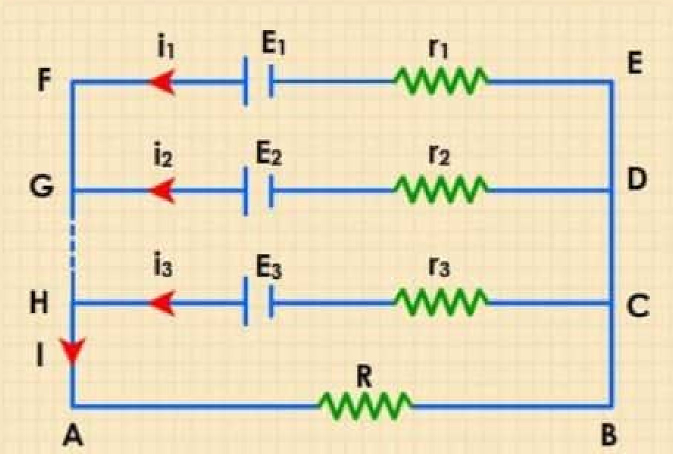
- E.M.F of battery = E.
- Total internal resistance of the combination of n cells = r/n
- Total resistance of the circuit = (r/n) + R

$$I = \frac{\text{net E.M.F}}{\text{Total Resistance}} = \frac{E}{(r/n)+R} = \frac{nE}{r+nR}$$

Case I If r < < R, the $I \cong nE/nR = E/R$; then total current obtained from combination is approximately equal to current given by one cells only.

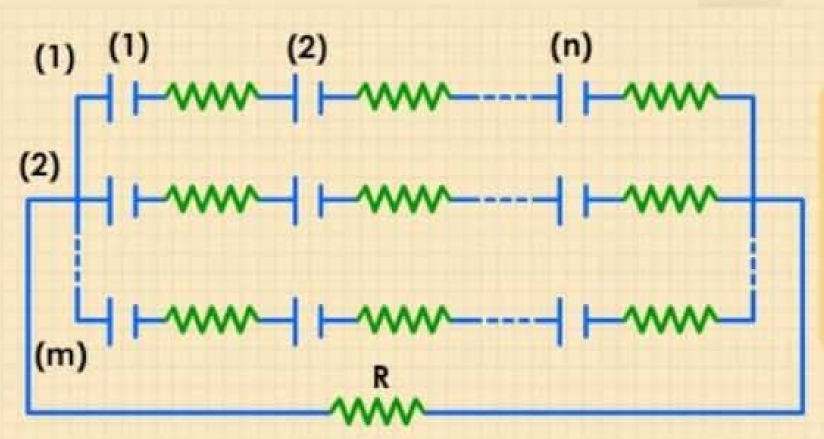
Case II If r > > R, then $I \cong nE/r$; then total current is approximately equal to n times the current given by one cell.

When E.M.F's and internal resistance of all the cells connected in parallel are different



$$I = \frac{\sum_{i=0}^{n} \frac{E_i}{r_i}}{1+R\sum_{i} \frac{1}{r_i}} \text{ and } E_{eq.} = \frac{\sum \frac{E_i}{r_i}}{\sum \frac{1}{r_i}}, \quad r_{eq.} = \frac{1}{\sum \frac{1}{r_i}}$$

3 CELL IN MIXED GROUPING



$$\text{Total resistance of the circuit} = \left[\left(\frac{nr}{m}\right) + R\right]$$

$$I = \frac{\text{net E.M.F}}{\text{Total Resistance}} = \frac{nE}{(nr/m)+R} = \frac{nmE}{nr+mR}$$

ELECTRICAL POWER

The energy liberated per second in a device is called its power. The electrical power P delivered by an electrical device is given by

$$P = \frac{dq}{dt}V \qquad P = VI \qquad P = I^2R \qquad P = \frac{V^2}{R} \text{ watt}$$

Part I

INSTRUMENTS MEASURING VARIOUS ELECTRICAL QUANTITIES

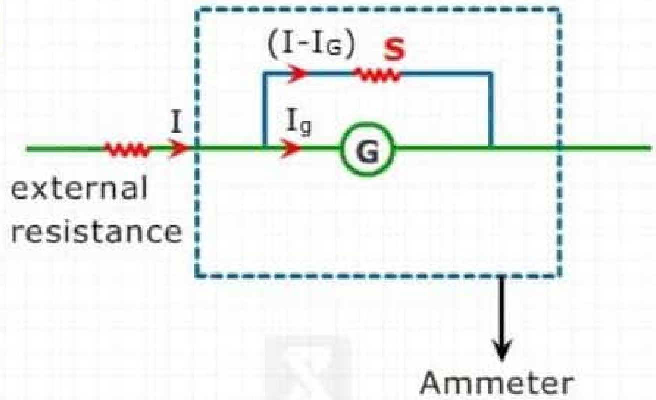
01 AMMETER

A shunt (small resistance) is connected is parallel with galvanometer to convert it into ammeter.

I_G = Current through galvanometer

R_G = Resistance of galvanometer

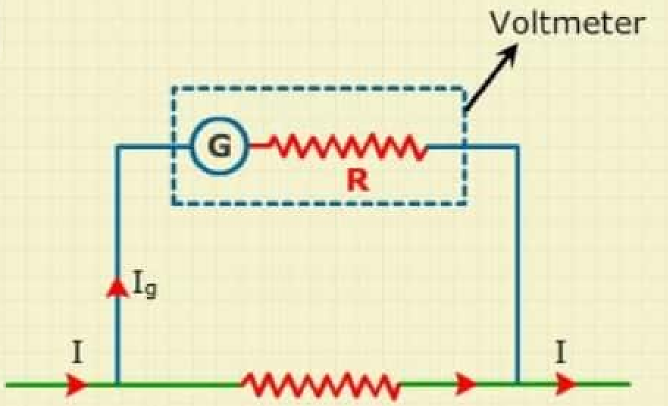
$$S = \frac{I_G R_G}{I - I_G}$$



02 VOLTMETER

A high resistance is put in series with galvanometer. It is used to measure potential difference across a resistor in a circuit.

$$I_G = \frac{V}{R_G + R}$$

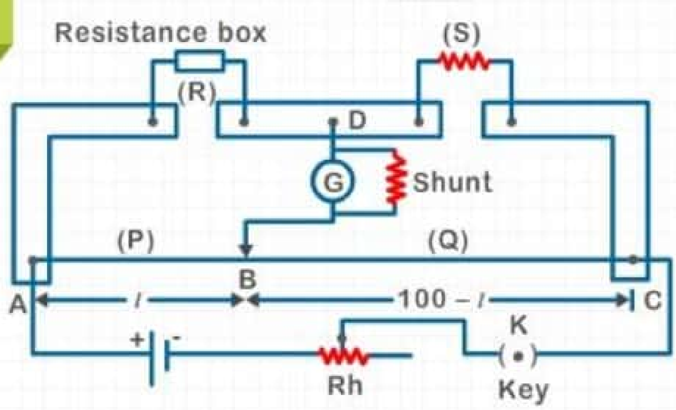


03 METRE-BRIDGE

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

R = Resistance taken in the resistance box

l = Length measured



POTENTIOMETER

Part II

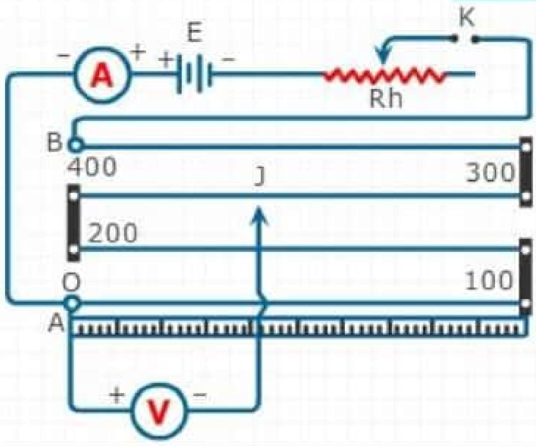
l = Length

A = Area of cross-section

ρ = Resistivity of material

I = Current

$$V = I\rho\frac{l}{A}$$



APPLICATION OF POTENTIOMETER

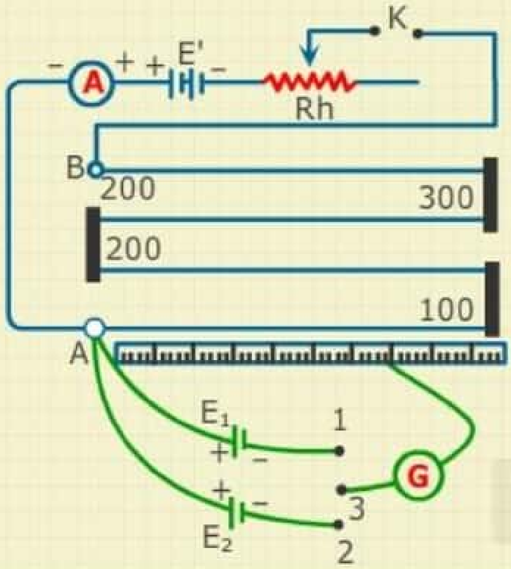
APPLICATION-01

To find EMF of an unknown cell and compare EMF of two cells

ℓ_1 = Balancing length when key is between gaps of terminal 1 and 2

ℓ_2 = Balancing length when key is between gaps of terminal 2 and 3

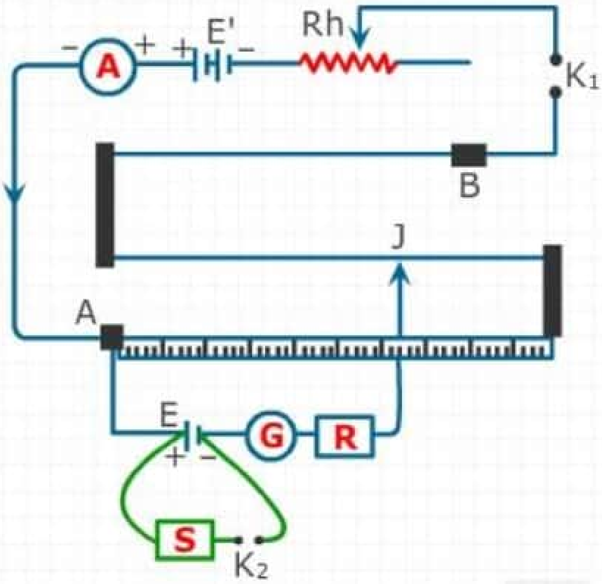
$$\frac{E_1}{E_2} = \frac{\ell_1}{\ell_2}$$



APPLICATION-02

To find the internal resistance of a cell

$$r' = \left[\frac{\ell_1 - \ell_2}{\ell_2}\right]$$



APPLICATION-03

To find current if resistance is known

$$I = \frac{X\ell_1}{R_1}$$