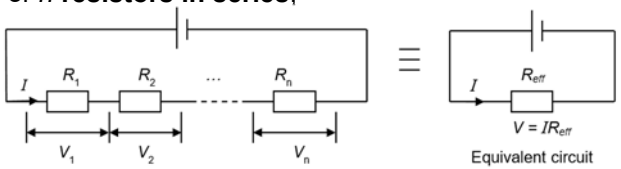
D.C. CIRCUITS

"**Potential**" refers to a value at a single point. Across a circuit component, current will flow from a point with higher potential to a point with lower potential.

"**Potential difference**" (p.d.) refers to the difference when we compare the potential values across the two ends of a circuit component.

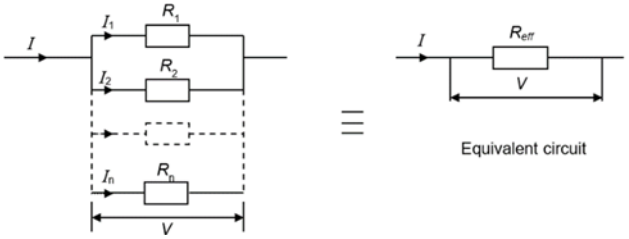
e.g. p.d. across a resistor, $V_{AB} = V_A - V_B$
If potential V_A > potential V_B, a current flows.
If $V_A = V_B$, $V_{AB} = 0$, no current flows.

For *n* **resistors in series**,



I is constant (same *I* flowing through each resistor)
$V = V_1 + V_2 + \ldots V_n$
$IR_{eff} = IR_1 + IR_2 + \ldots IR_n$
$R_{eff} = R_1 + R_2 + \ldots R_n$

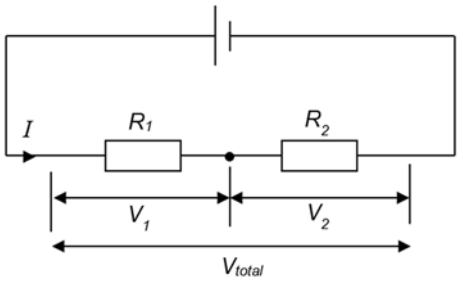
For *n* **resistors in parallel**,



V is constant (same p.d. across each resistor)
$I = I_1 + I_2 + \ldots I_n$
$V/R_{eff} = V/R_1 + V/R_2 + \ldots V/R_n$
$1/R_{eff} = 1/R_1 + 1/R_2 + \ldots 1/R_n$
R_{eff} is always less than the value of smallest individual resistance *R*.

Potential Divider

(for resistors connected in series)



$$I = \frac{V_{total}}{R_{total}} = \frac{V_{total}}{R_1 + R_2}$$

$$V_1 = IR_1 = \frac{R_1}{R_{total}} V_{total} \; ; \; V_2 = IR_2 = \frac{R_2}{R_{total}} V_{total}$$

Ratio of p.d. across the two resistors $\frac{V_1}{V_2} = \frac{R_1}{R_2}$

In general,

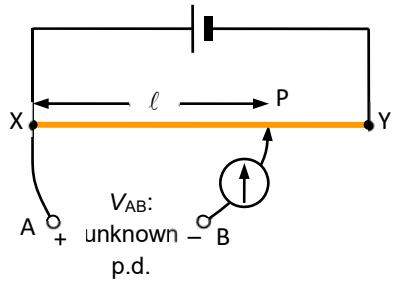
$$V_R = \frac{R}{R_{total}} V_{total} \quad \text{or} \quad \frac{V_R}{V_{total}} = \frac{R}{R_{total}}$$

Practical uses of potential divider circuit

Thermistor is a semiconductor whose resistance R_t changes with temperature. Most thermistors have a *negative temperature coefficient* (NTC), meaning its resistance *decreases* as temperature *increases.*

Light-Dependent Resistor (LDR) is a semiconductor whose resistance *decreases* as light intensity falling on them *increases*.

Potentiometer

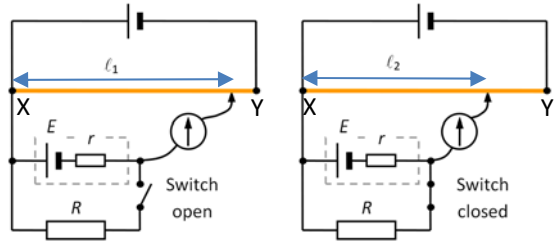


Galvanometer shows null deflection: $V_{XP} = V_{AB}$
Applying potential divider & $R \propto \ell$,

$$\frac{V_{XP}}{V_{XY}} = \frac{L_{XP}}{L_{XY}} \quad \text{or} \quad V_{XP} = \frac{V_{XY}}{L_{XY}} L_{XP}$$

Potentiometer is like an ideal voltmeter (which draws no current).

Determining unknown internal resistance *r*



Switch opened: Whether or not *E* has *r* and independent of value of *r* (since there is no current passing *r*), ℓ_1 will not change. $E = \frac{V_{XY}}{L_{XY}} \ell_1$

Switch closed: $V_R = \frac{ER}{R+r} = \frac{V_{XY}}{L_{XY}} \ell_2 \Rightarrow \frac{R}{R+r} = \frac{\ell_2}{\ell_1}$