Internal Resistance & Dry Cells

Every dry cell can be considered as being made up of two parts. In the diagram these parts have been separated and represented by the symbols (+|I−) and (⁓⁓)

One part (+|I−) **gives** the coulombs an ideal amount of energy **($+V_{id}$)**

The other part (⁓⁓) **takes** energy from the coulombs **($-V_{int}$)**as they move through the cell. This is called **Internal Resistance**. It acts much like an invisible load inside the cell.

In the diagram the measure voltage across the cell would be **(V_T)**

Mathematically $V_T = +V_{id} - V_{int}$

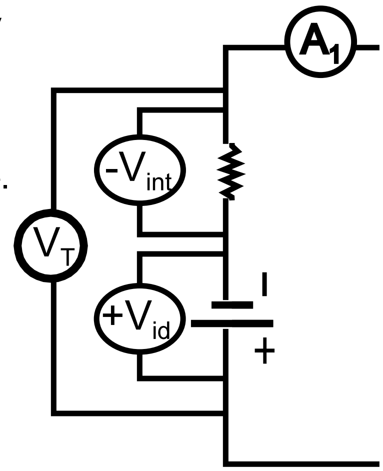

Diagram 1

Internal Resistance can not be separated from the cell because coulombs need energy to move through any real material (including cells). Coulombs need very little energy to move through conductors. When coulombs move through loads they need (or convert to other forms or lose) more energy. The more coulombs that move through something the more energy that is converted to other forms. Another way of saying this is; The more current flowing through something the more energy is lost.

In Diagram 1 (above right) the circuit is open so no current flows (A_1=0) Since no coulombs flow through the cell, no energy is lost to the internal resistance(**$-V_{int}$** = 0). Let's assume the ideal amount of energy the cell can give the coulombs is 6.5 Volts **($+V_{id}$= 6.5V)**

Therefore mathematically

$$\begin{aligned} V_T &= +V_{id} - V_{int} \\ &= 6.5 - 0 \\ &= 6.5 \text{ Volts} \end{aligned}$$

Now let's connect one load or bulb (Diagram 2). Since current now flows ($A_1 \neq 0$) These coulombs flowing through the cell lose some energy to the internal resistance. Let's assume (**$-V_{int}$** = 0.5 V). The ideal amount of energy the cell can give the coulombs is still 6.5 Volts **($+V_{id}$= 6.5V)**
Since some energy is lost moving through the cell the measure voltage across the cell **(V_T)** appears to drop

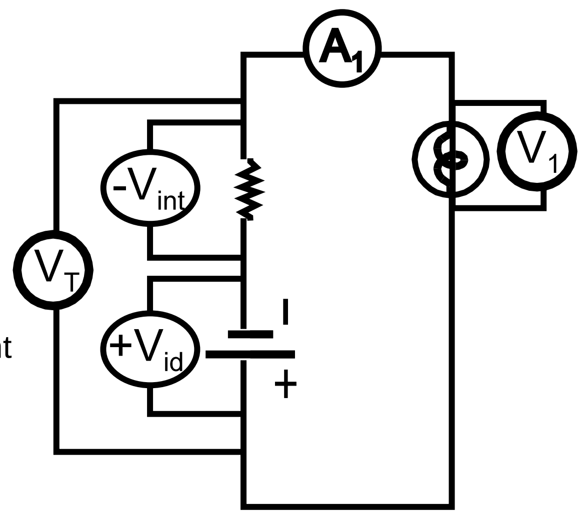

Diagram 2

Mathematically

$$\begin{aligned} V_T &= +V_{id} - V_{int} \\ &= 6.5 - 0.5 \\ &= 6.0 \text{ Volts} \end{aligned}$$

Note the energy gain across the cell equals the energy lost across the bulb (load) $V_T = V_1$ = 6.0V

Now let's connect two loads or bulbs (Diagram 3) . Since there are two bulbs in series in the circuit, less current flows ($A_{2\ bulbs}$<$A_{1\ bulb}$). Less energy is lost to the internal resistance because fewer coulombs are flowing . Let's assume (**$-V_{int}$** = 0.25 V). The ideal amount of energy is still 6.5 Volts **($+V_{id}$= 6.5V)** Since less energy is lost moving through the cell, the measured voltage across the cell **(V_T)** appears to increase

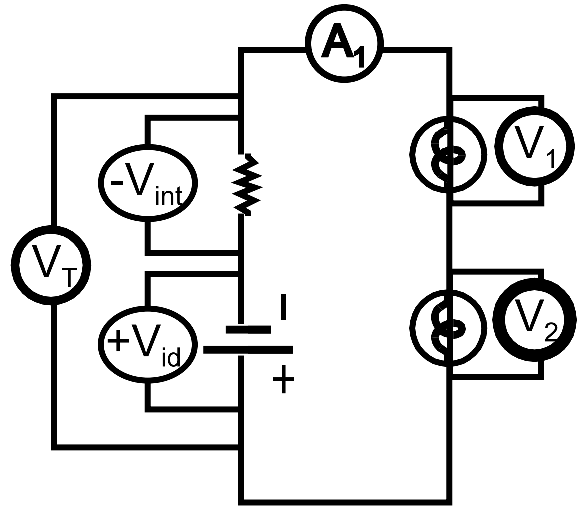

Diagram 3

Mathematically

$$\mathbf{V_T} = \mathbf{+V_{id} - V_{int}} = 6.5 - 0.25 = 6.25 \text{ Volts}$$

Note the energy gain across the cell equals the total energy lost across the bulbs **V_T** = **V_1+V_2** = 6.25V

It looks like voltage across the cell increases. A better way of looking at it would be that less energy is lost flowing through the cell.

Predict what would happen to the measured voltage across the cell if three bulbs are connected in series.