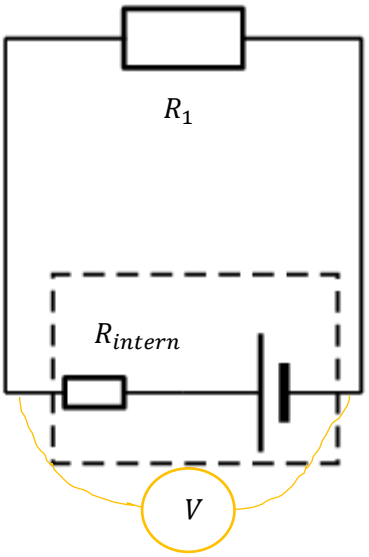
Electric circuits
(Internal resistance)

Table of content

1. Internal resistance.

With the previous circuits we did not work with the battery's internal resistance. The internal resistance of the battery can not be ignored and has an effect on the circuit.



Important concepts

V_{EMF} = reading on the voltmeter over the cells when the switch in the main current is open.

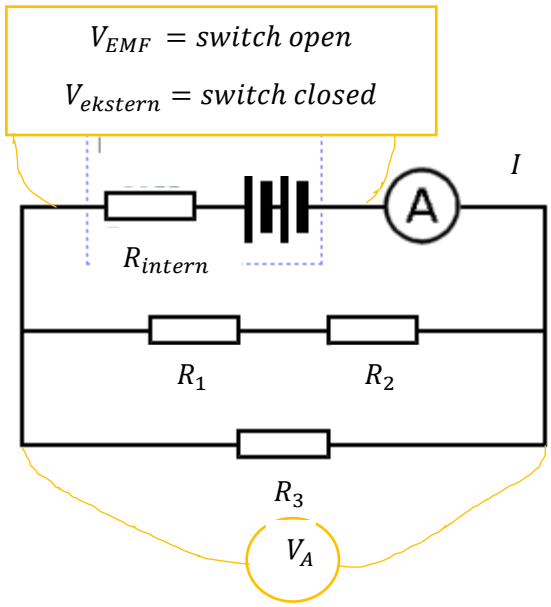
$V_{ekstern}$ = reading on the voltmeter over the cells when the switch is in the mainstream is closed.

V_{intern} = This is the difference in the readings on the voltmeter over the cells when the switch in mainstream is open and closed.

$$V_{intern} = V_{EMF} - V_{ekstern}$$

IMPORTANT: The voltmeter reading drops when the mainstream switch goes open because the battery provides internal resistance and therefore energy remains inside the cell

2. Application



To calculate the total resistance we must count the internal resistance together with the external resistance

$$R_{total} = R_{intern} + R_{ekstern}$$
$$R_{ekstern} = R_{parallel}$$
$$\frac{1}{R_{parallel}} = \frac{1}{R_1 + R_2} + \frac{1}{R_3}$$

To calculate the potential difference, we use the basic concept of external and internal potential difference.

$$V_{intern} = V_{EMK} - V_{ekstern}$$
$$V_{EMK} = V_{ekstern} + V_{intern}$$

Note that in the specific example, the potential difference across the parallel circuit is the same as the external potential difference.

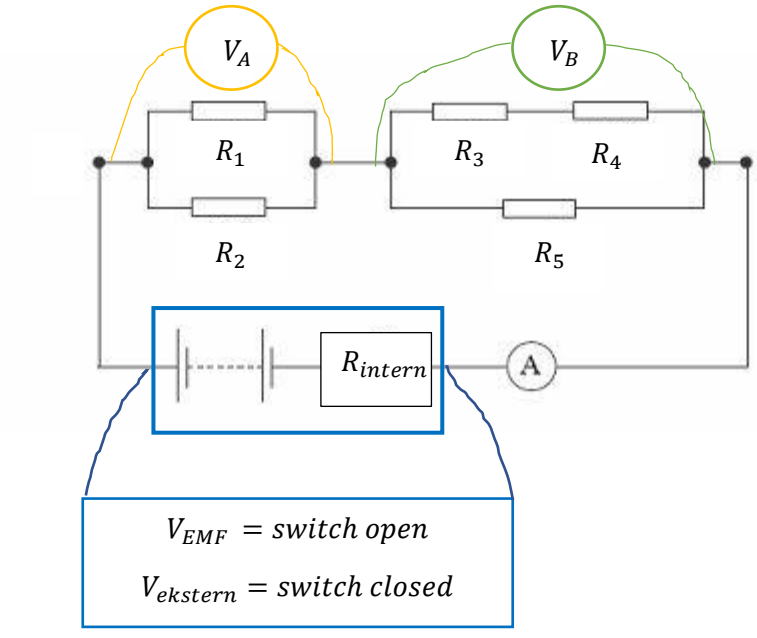
$$V_A = V_{ekstern}$$

To calculate the main current there are different routes that can be followed. It is only important to always make sure the values match each other.

$$I = \frac{V_{EMF}}{R_{totaal}}$$

$$I = \frac{V_{ekstern}}{R_{ekstern}}$$

$$I = \frac{V_{intern}}{R_{intern}}$$



To calculate the total resistance, the following must be done:

$$R_{total} = R_{intern} + R_{ekstern}$$

$$R_{ekstern} = R_{parallel\ A} + R_{parallel\ B}$$

$$\frac{1}{R_{parallel\ A}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{parallel\ B}} = \frac{1}{R_3 + R_4} + \frac{1}{R_5}$$

The potential differences of the circuit are as follows:

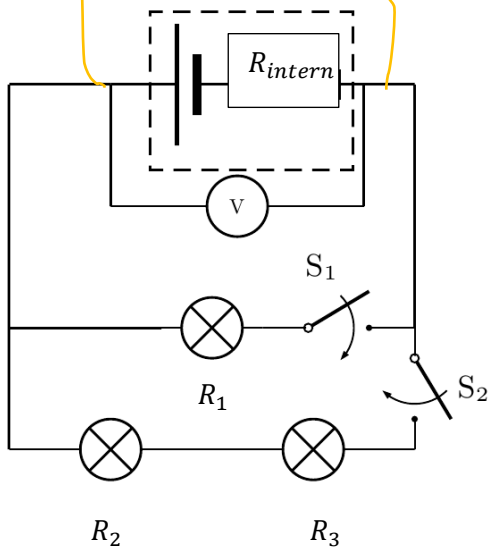
$$V_A = V_1 = V_2$$

$$V_B = V_{3+4} = V_5$$

$$V_{ekstern} = V_A + V_B$$

V_{EMK} = *switch open*

$V_{ekstern}$ = *switch closed*



(Switch 1 and 2 closed)

The first remark that can be made in the example is that the resistors are in parallel. We know that the potential difference across a parallel circuit in each branch will be the same as the external potential difference

$$V_{ekstern} = V_1 = V_2 + V_3$$

Note that the potential difference across the second branch is the same as the external potential difference, but the potential difference across resistor two is not the same as the potential difference across resistor 3. The potential difference of the two resistors together will be the same as the external potential difference.

$$V_2 \neq V_3$$
$$V_{ekstern} = V_2 + V_3$$

Theory

When they ask if the current or voltage will increase decrease or stay the same, we use the RIVV method.

$R_{total} =$

$I_{total} =$

$V_{intern} =$

$V_{ekstern} =$

When a switch is added or removed, the total resistance increases decreases or stays the same. We use ohm's law to make the following conclusions:

$$\uparrow R_{total} \quad \downarrow I_{total}$$

$$\downarrow R_{total} \quad \uparrow I_{total}$$

The following happens when calculating the external potential difference:

$$\uparrow R_{total} \quad \downarrow I_{total} \quad \downarrow V_{intern} \quad \uparrow V_{ekstern}$$

$$\downarrow R_{total} \quad \uparrow I_{total} \quad \uparrow V_{intern} \quad \downarrow V_{ekstern}$$

A easy way to remember the above information is to see that the total resistance and external potential difference will always increase or decrease together, and the total current and internal potential difference will also increase or decrease together.

IMPORTANT: The emf of the battery will always stay constant except when the battery cells are changed. We know that:

$$V_{EMK} = V_{ekstern} + V_{intern}$$

The external potential difference increases when the internal potential difference decrease.

Example

Switch S_1 *and* S_2 are both closed.

$$S_1 = closed \quad S_1 = open$$

What will happen with the total resistance, total current, internal and external potential difference?

$$R_{total} = \uparrow$$

$$I_{total} = \downarrow$$

$$V_{intern} = \downarrow$$

$$V_{ekstern} = \uparrow$$