Physics II

Kirchhoff's laws, Circuits
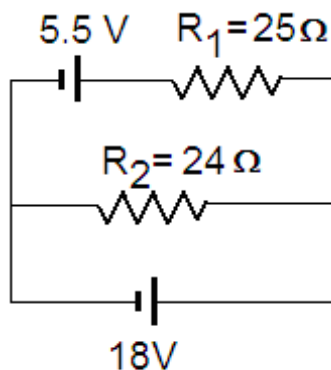
Kirchhoff's law for loops

In an electric circuit, the sum of voltages in a closed loop is zero.
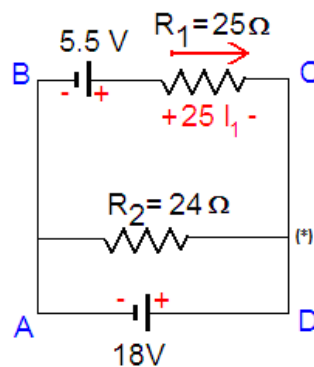
Kirchhoff's law for nodes

The sum of the currents entering a node is equal to the sum of the currents that leave the node.

This law is equivalent to say that there are no sources or sinks of charge.

Example.- Determine the magnitude and direction of the currents in resistors R_1 and R_2 and the 18V source.

Solution: First, we can focus on the external loop marked ABCD in the figure. If we assume the current goes from left to right in R_1, the voltage across will be as indicated in the figure below.

We apply Kirchhoff's law for loops. A practical rule to apply this law is to follow the loop using the sign at the end of each device in the circuit.

In this example when going from A to B there is no voltage, from B to C we pass the 5.5V source when we use the positive sign, then we pass R_1 using the negative sign, from C to D there is no voltage and from D to A we pass the 18V source with a minus sign.

The equation is:

$$5.5 - 25I_1 - 18 = 0$$

Solving for I_1 we get

$$I_1 = \frac{5.5V - 18V}{25\Omega} = \textbf{- 0.50 A}$$

The minus sign in this result indicates that are our initial assumption was not correct. The current goes from right to left in R_1.

The case of R_2 is simpler because it is connected in parallel with the 18V power supply, so according to Ohm's law:

$$I_2 = \frac{18V}{24\Omega} = \textbf{0.75 A}$$

This current also goes from right to left because in resistors the current flows from higher to lower potential.

Finally, to find the current through the 18V source we apply Kirchhoff's law for the node marked with an asterisk. From that node two currents go out of 0.75A and 0.5A, so the current entering from the 18V source has to be 1.25A.

$$I_{source} = \textbf{1.25 A}$$