VOLTAGE SOURCE

ELECTROMOTIVE FORCE

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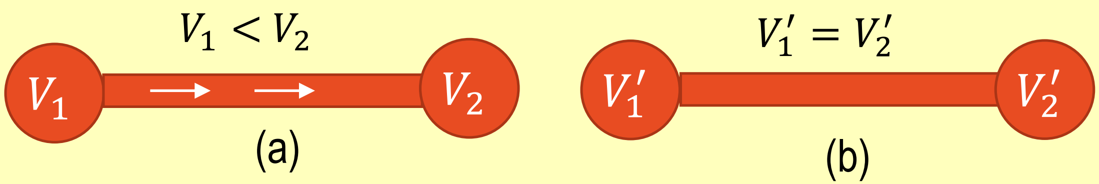
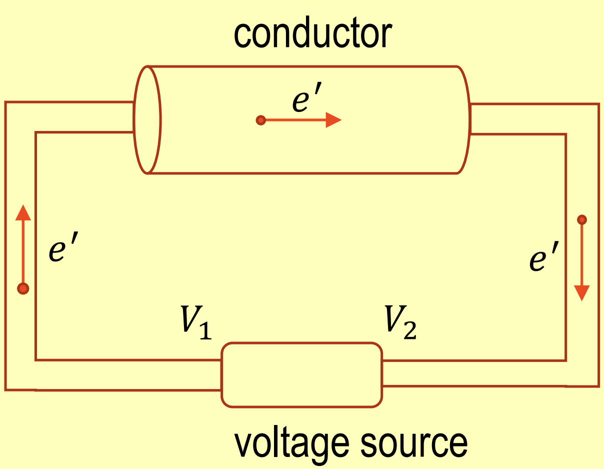


picture 1

- If there is a potentials difference between the ends of conductor (picture 1-a), then the charged particles move from one end of conductor to another - current flows.
- If there is no difference in potentials (picture 1-b), then there is no current in conductor.

We conclude that:
when the current flows through the conductor sufficiently long time, then it is necessary to continuously maintain the potential difference between any two points of the conductor.

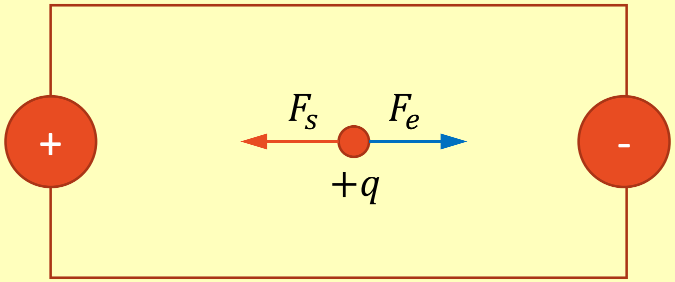


picture 2

In most electric circuits, the moving charged particles are negatively charged particles that are always present in the wires and other components of the electric circuit. The negatively charged particles can move only when there is a continuous electric circuit from one end of the device to the other (picture 2).
The motion of the charged particles is possible only if there is a device in the electric circuit where the process of separation of the charge particles is carried out continuously and potential difference is maintained at the end of this device. Such device is called **voltage source (battery).**

An voltage source is a two-pole device that maintains a fixed voltage across its poles.

▪ working principle



picture 3

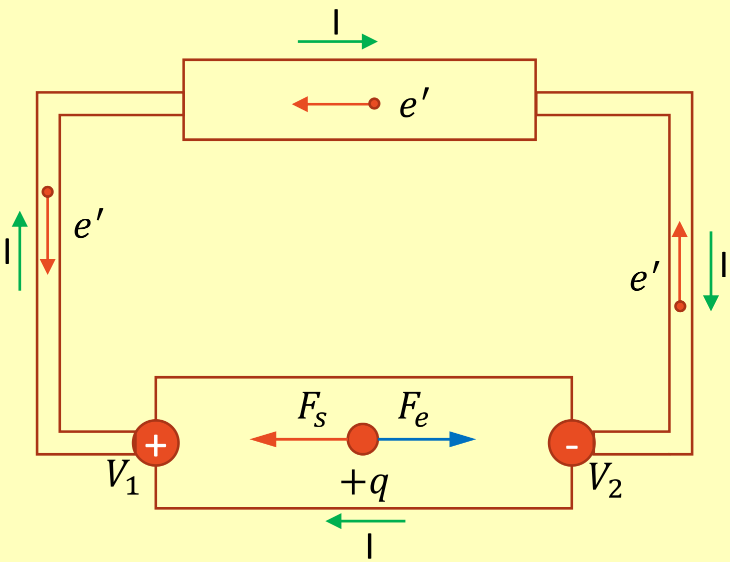
If only electric field acts on the charge carriers, the charge flows through the wire from the higher potential to the lower potential (positive carriers) and this would lead to the equalization of potentials and stopping of the current. To maintain a current for sufficiently long time it is necessary to have the aid of forces of non-electrostatic origin, called extraneous forces.(picture 3).

The extraneous forces move the positive charge carriers from the lower potential (negative pole) back to the higher potential (positive pole). This force is directed from negative pole towards the positive pole.
Within the source, the electric field is directed from the positive pole towards the negative pole. The electric field between poles will exert a electric force on this moving charges and electric force is in the opposite direction to extraneous forces.

If the process of separating opposite charges within an source is carried out then, on negative pole there are an excess of negative charges and on positive pole there are an same excess of positive charges (a voltage source maintains a constant change in electric potential across its poles). So, the magnitude of the extraneous force is equal to the magnitude of the electric force.

In practice, process of separating opposite charges is carried out by some chemical or thermal process, magnetic field etc…Separated charges at the poles have electrostatic potential energy. This enegy is called electric energy.

We conclude that (in the sources) internal energy, mechanical energy, light energy, or some other energy converts into electric energy.



picture 4

When connected to a circuit, the potentials difference (voltage) between the poles creates an electric force on the charges in the conductor causing them to move and establishing an electric current.
Since electrons are negatively charged, they flow away from the negative pole and towards the positive pole. This is in the opposite direction to conventional current, so conventional current assumes that current flows out of the positive pole, through the circuit and into the negative pole of the source (the potential difference between the poles does not decrease, because the extraneous force continuously separates the charges).

The extraneous force in the voltage source causes the electrons to move from negative to positive pole (or the positive charge carriers move from negative to positive pole) – so, the current in the voltage source flows from negative to positive pole.

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Extraneous forces can be characterized by the work they do on charges travelling along a circuit. The quantity equal to the work done by the extraneous forces on a unit positive charge is called the electromotive force (e.m.f.) ε acting in a circuit or on a section of it. Hence, if the work of the extraneous forces on the charge q is *W*, then:

$$\varepsilon = \frac{W_S}{q}$$

We conclude that the dimension of the electromotive force (e.m.f). is measured in the same units as potential difference (voltage). It is measured in joule per coulomb or volts (V).

When the voltage source is not connected to the conductor, then there is no current in voltage source and the magnitude of the electrostatic force is equal to the magnitude of the extraneous force.
The absolute value of the work done by the electrostatic force on a charge carriers, as they move between the poles is equal to the absolute value of the work done by the extraneous force on a positive charge carriers as they move between the poles. If the positive pole has a potential V_+ and the negative pole has a potential V_- then:

$$W_e = W_s \Rightarrow q(V_+ - V_-) = q\varepsilon \Rightarrow \varepsilon = V_+ - V_-$$

Electromotive force (emf) is equal to the difference of electric potential between the poles (positive and negative pole), when no current is flowing.

When the voltage source is connected to the conductor, then there is current in voltage source, and the resistance forces act on the charge carriers. Therefore, the magnitude of the electrostatic force is not equal to the magnitude of the extraneous force, and the absolute value of the work done by the electrostatic force on a charge carriers, as they move between the poles is not equal to the absolute value of the work done by the extraneous force on a positive charge carriers as they move between the poles.
Keep in mind that, the magnitude of electromotive force and voltage between the poles also change.