VŠB TECHNICKÁ UNIVERZITA OSTRAVA | FAKULTA ELEKTROTECHNIKY A INFORMATIKY

Fundamentals of Electrical Engineering

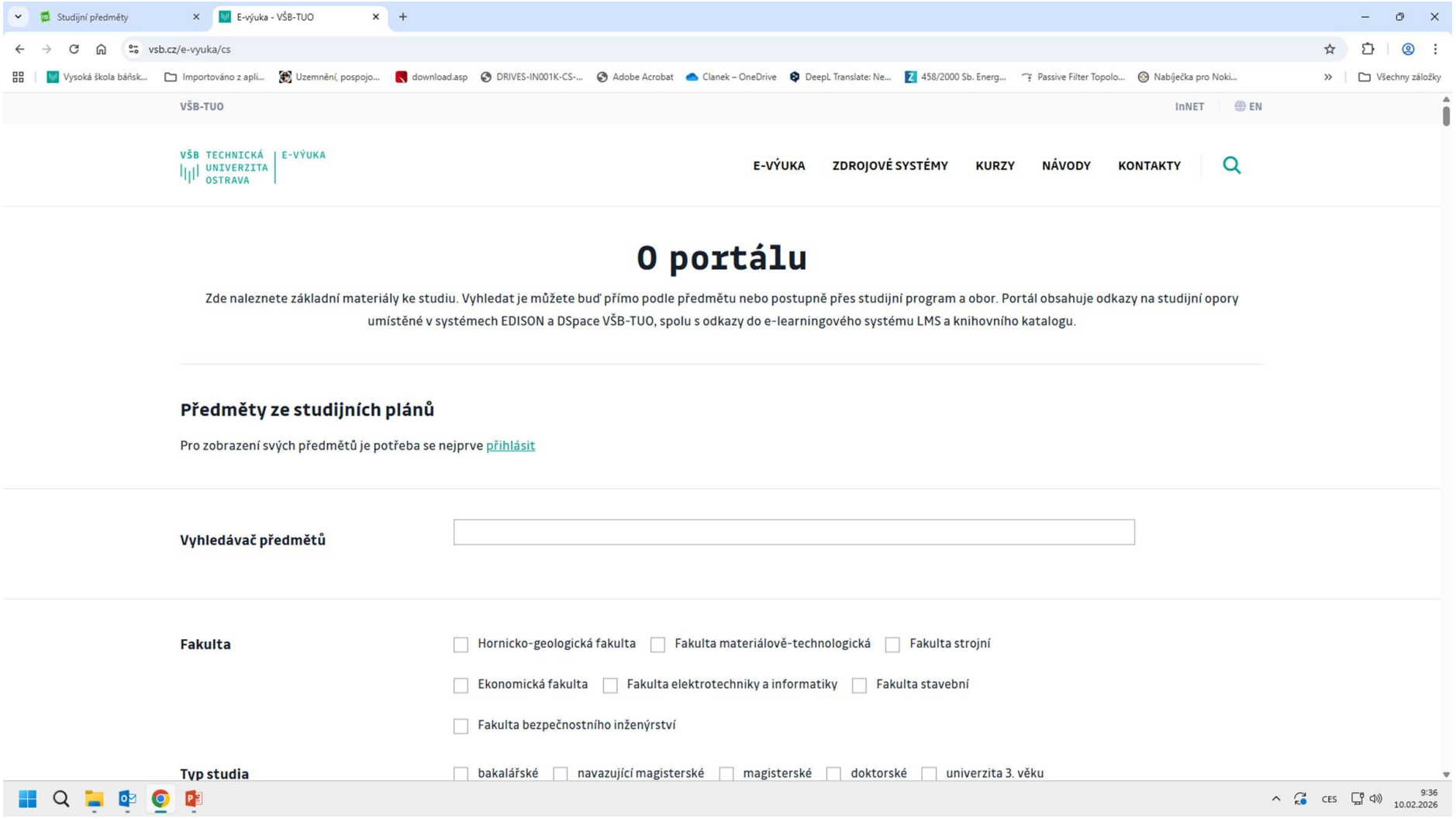
1. BASIC LAWS, ELECTRICAL SOURCES

Doc. Ing. Stanislav Kocman, Ph.D.

20. 10. 2022, Ostrava

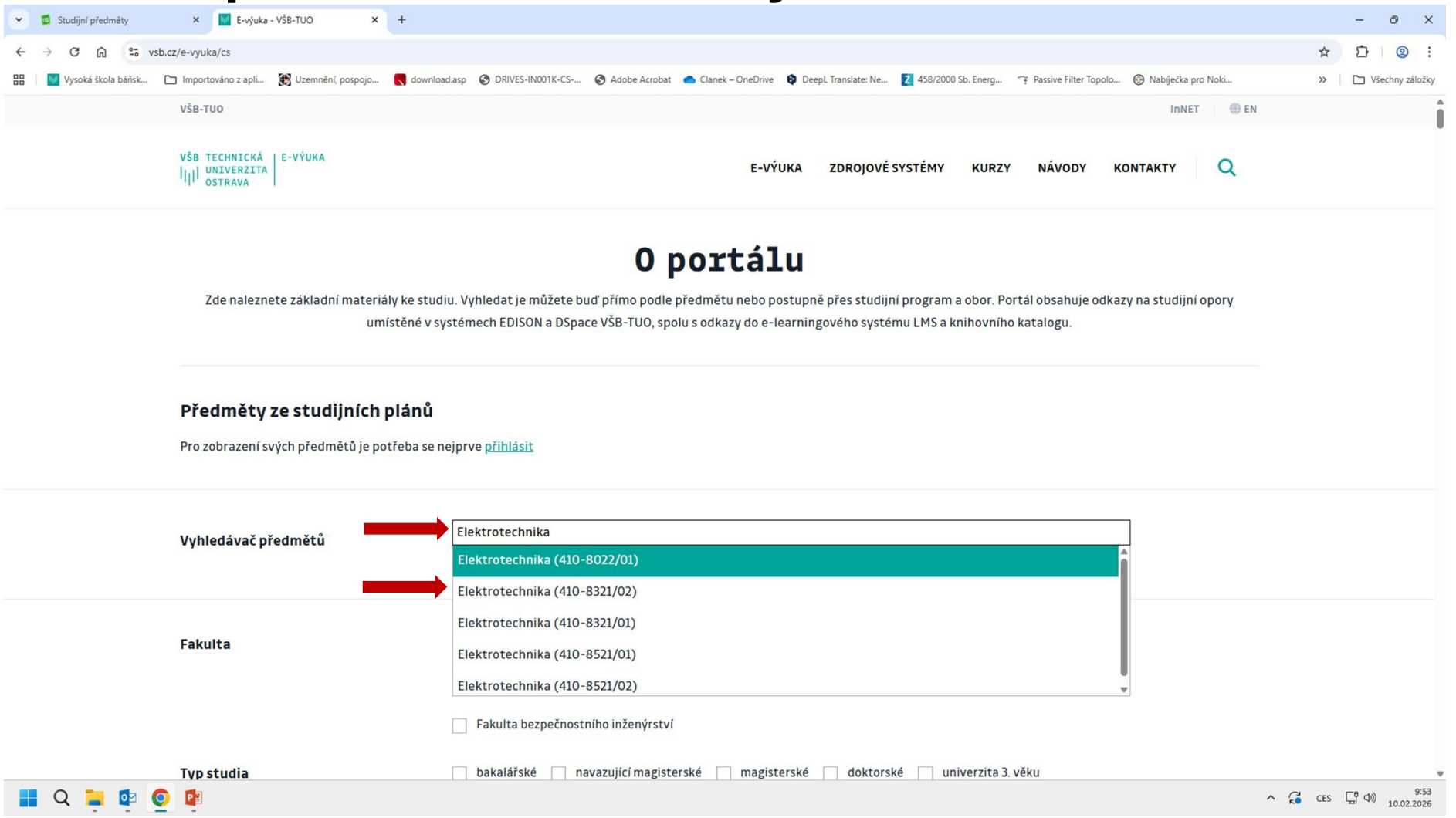
Study materials

- **Lectures and exercises: https://www.vsb.cz/e-vyuka/cs**



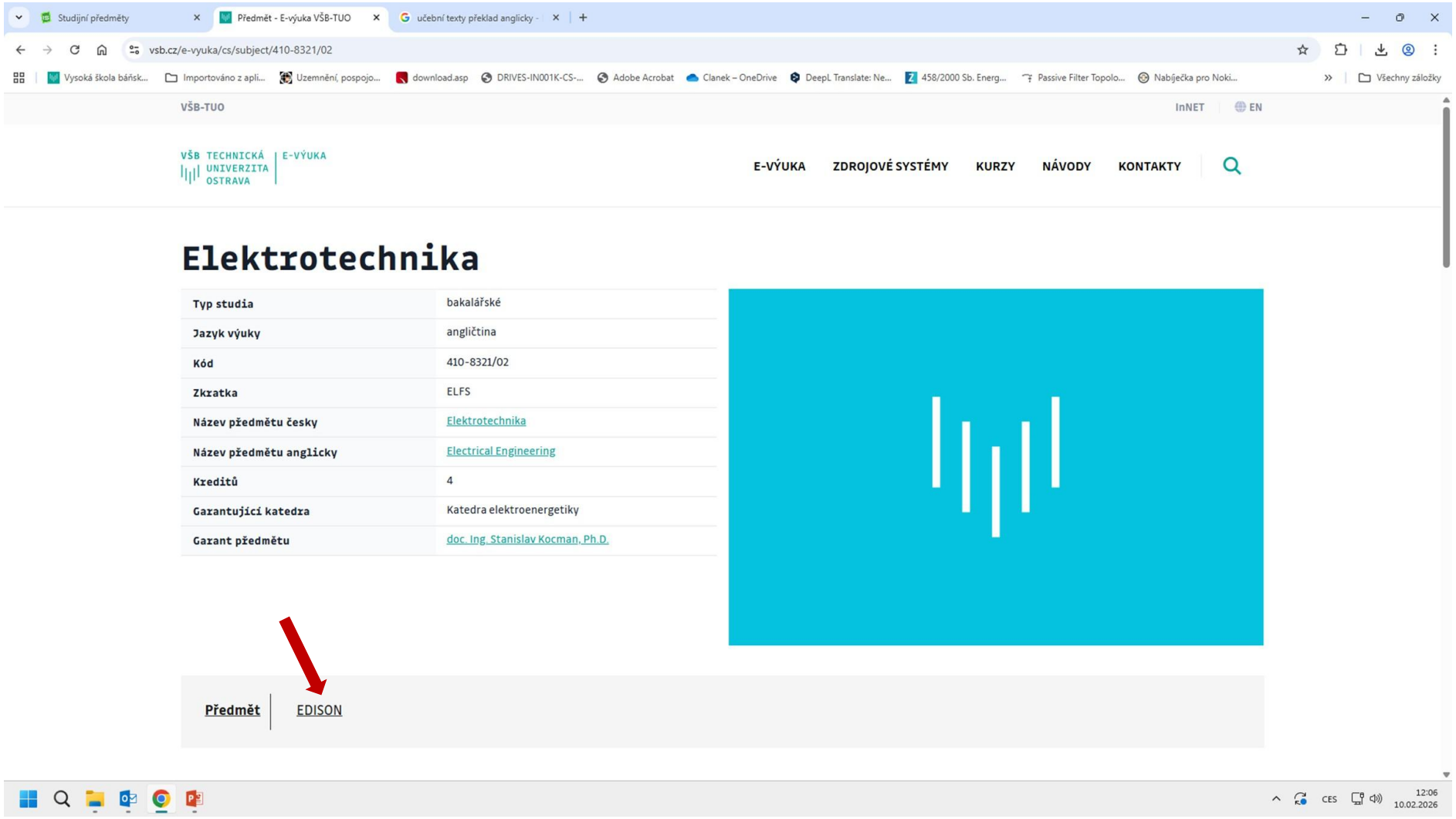
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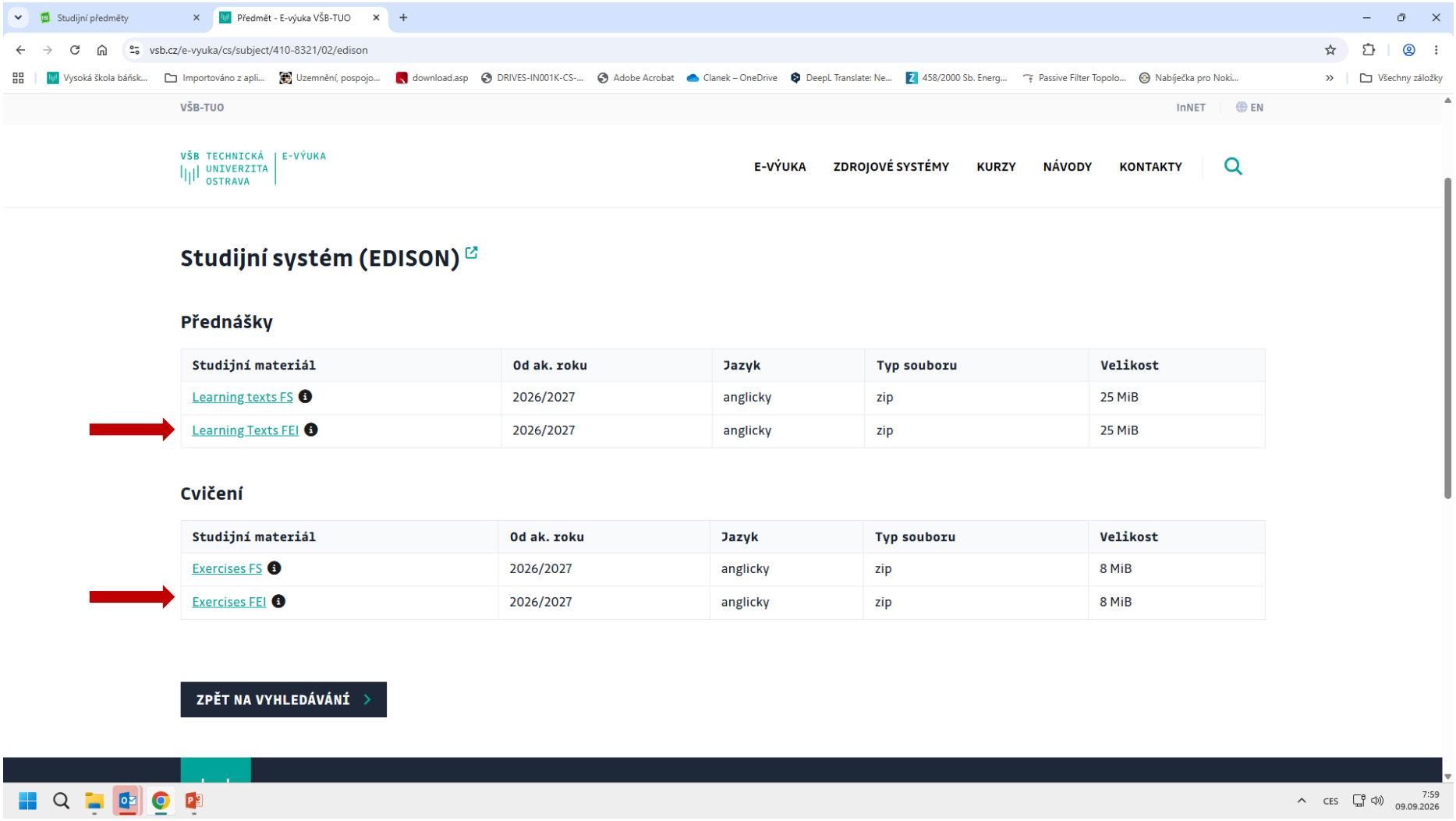
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Study materials

- Lectures and exercises: https://www.vsb.cz/e-vyuka/cs

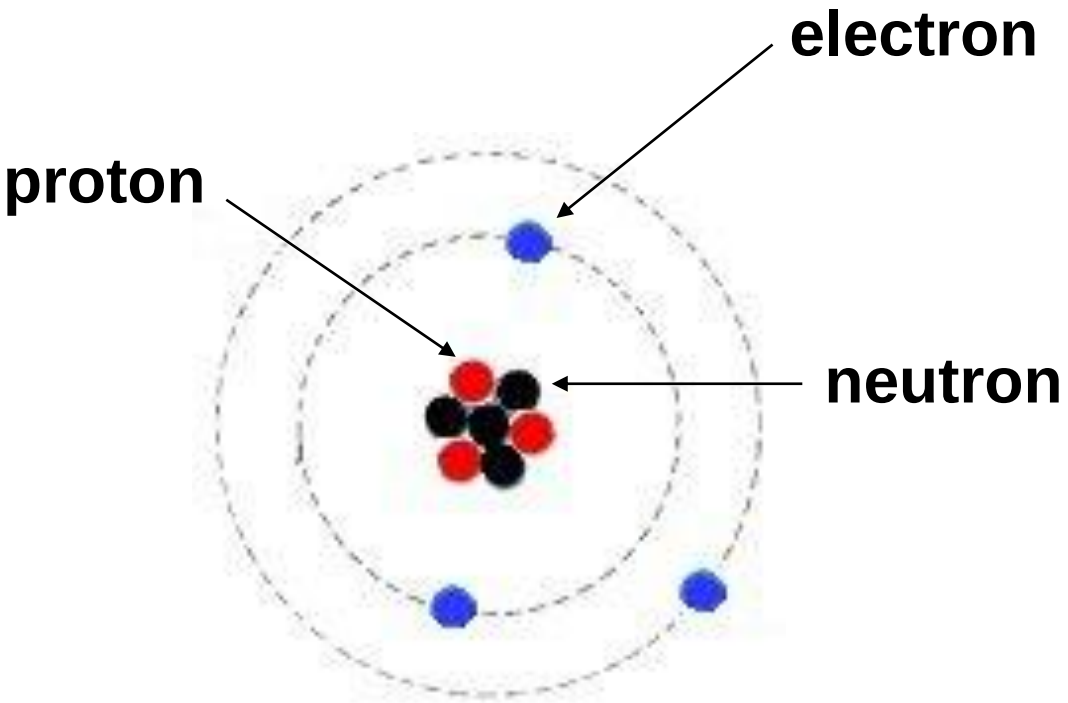


LECTURE PLAN

- **Ohm´s and Kirchhoff´s laws and their applications**
- **elementary electrical circuit, characteristics of its components**
- **classification of voltage sources, principle of operation, application**
- **characteristics and conditions of voltage sources**

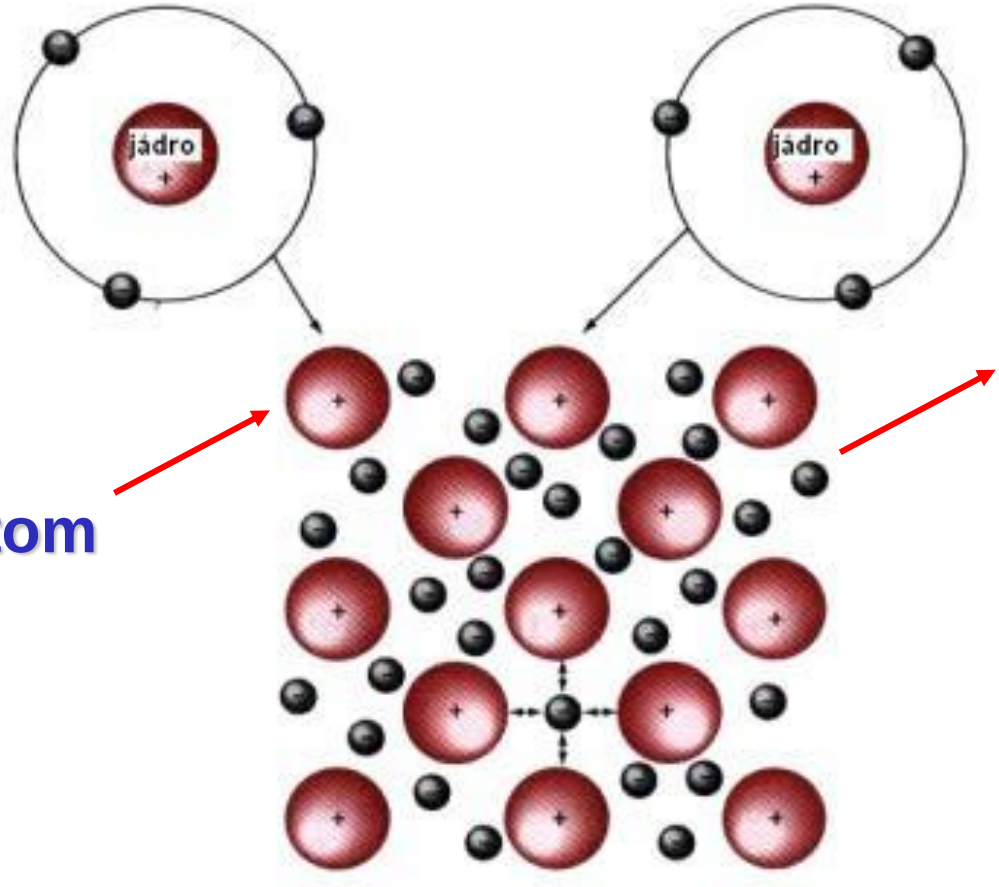
Fundamentals of electricity

- Atom structure



- Elementary charge: +(-) 1,602 * 10^{-19} C

Diagram of metallic coupling

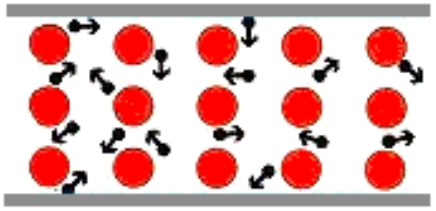


Free electron

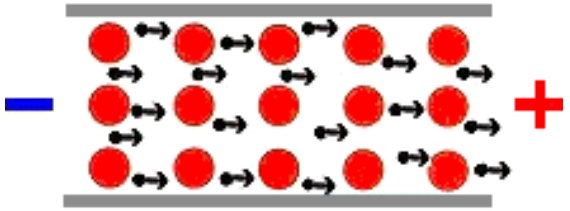
Nucleus of atom

Electrical current

- **METAL CONDUCTOR:** straight movement of free electrons



No electrical field (voltage) applied

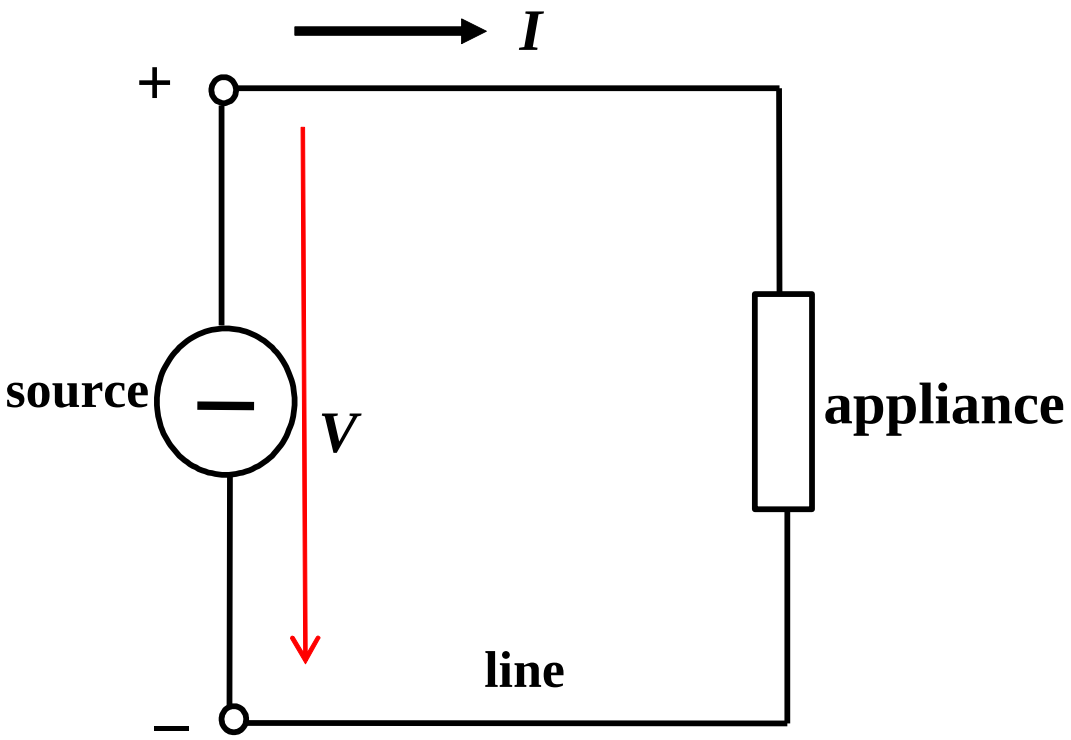


Electrical field (voltage) applied

- **USED METALS:**
  - Copper, aluminum, silver, gold, iron and their alloys
- **DILUTED ACID AND SALT**

Elementary electrical circuit

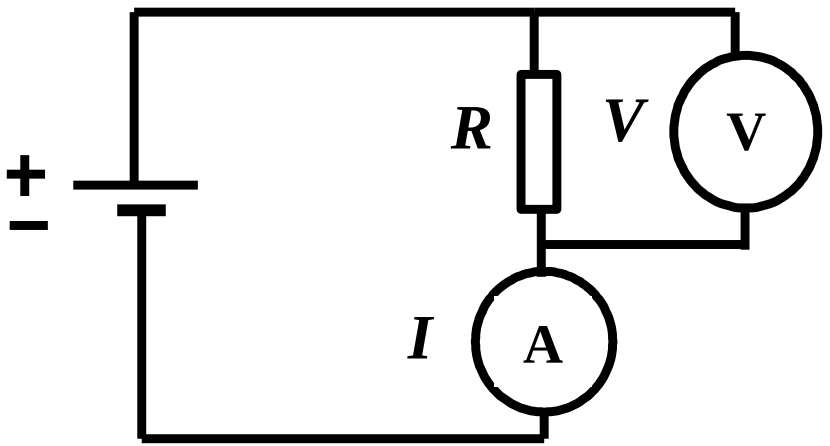
- source: electrical device that supplies electric power to an electrical load
- line: enables movement of electrical energy from the source to an electrical load
- appliance: consumes electric power

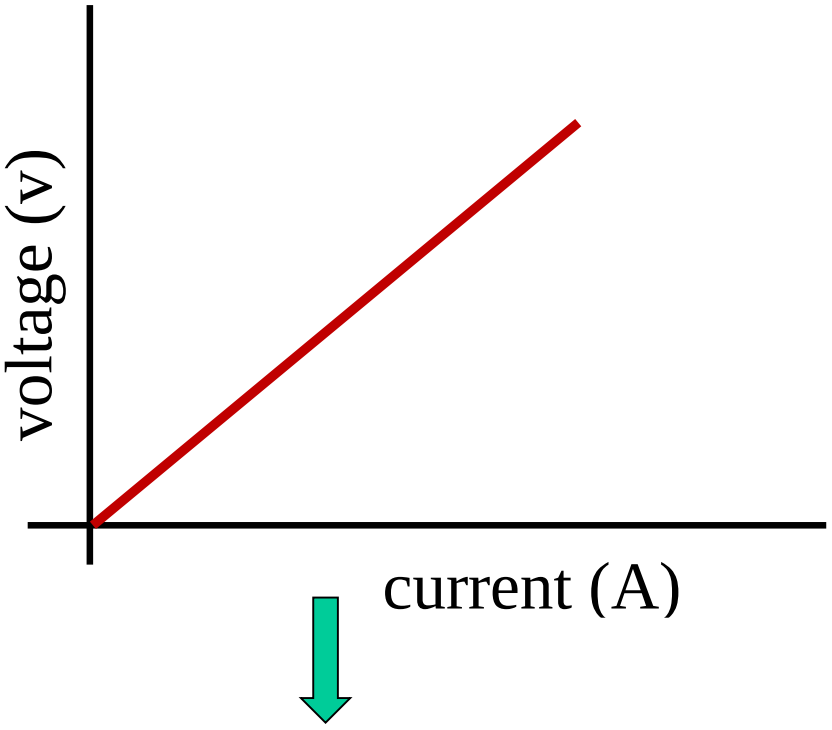


Ohm´s and Kirchhoff´s laws and their applications

- **Ohm´s law**

Measured circuit

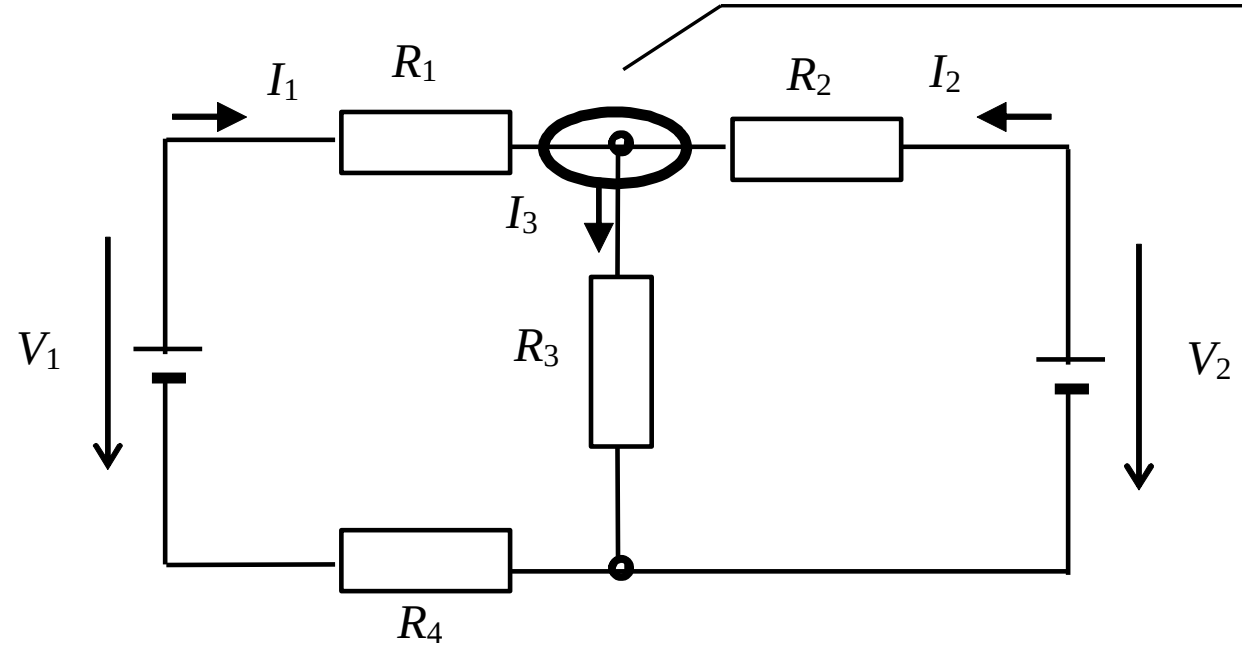


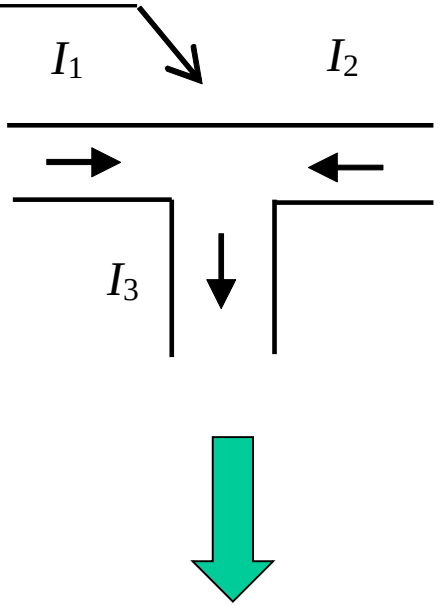


$$R = \frac{V}{I}, \quad R = \text{const. for } \vartheta = \text{const.} \Leftarrow V = \text{const} \cdot I = R \cdot I \,(\text{V}, \Omega, \text{A})$$

$$R = \rho \cdot \frac{l}{S} \ (\Omega)$$ ρ= resistivity: temperature dependent $\Rightarrow$ $$R_\vartheta = R_{\vartheta 0} \cdot \left[1 + \alpha \cdot (\vartheta - \vartheta_0)\right]$$

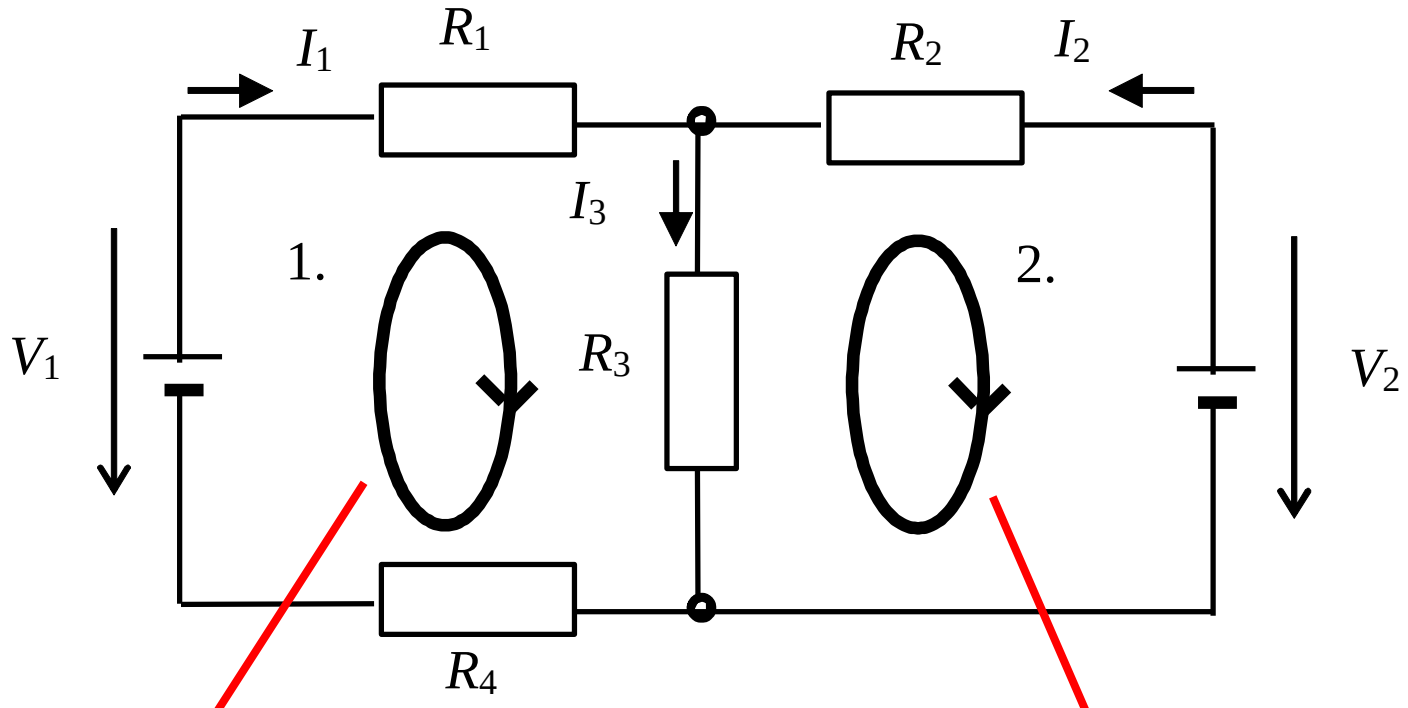
- **The first Kirchhoff´s law**





$$I_1 + I_2 - I_3 = 0 \rightarrow \sum I = 0$$

- **The second Kirchhoff´s law**

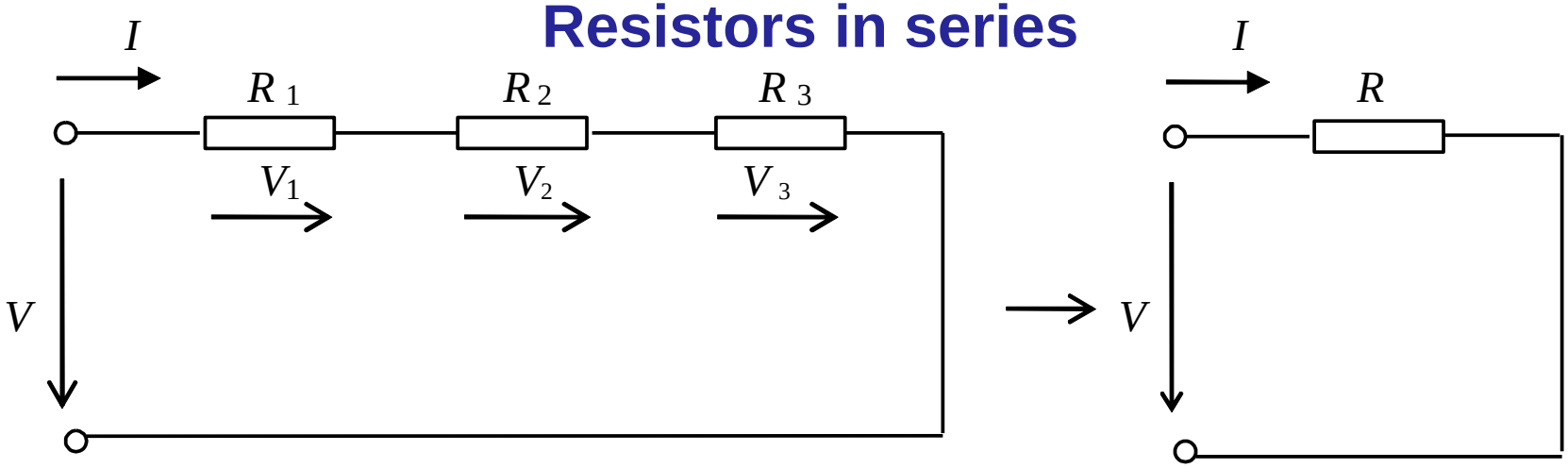


$$1.\ -V_1 + R_1 \cdot I_1 + R_3 \cdot I_3 + R_4 \cdot I_1 = 0 \qquad 2.\ V_2 - R_3 \cdot I_3 - R_2 \cdot I_2 = 0$$

$$\sum V = 0$$

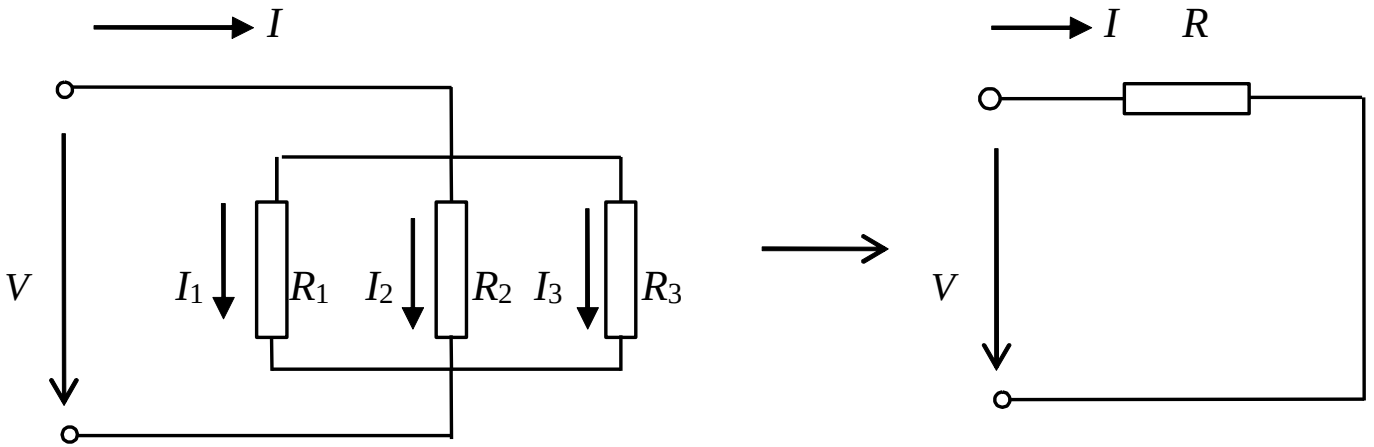
- **Applications**

Resistors in series



$$V = V_1 + V_2 + V_3 = R_1 I + R_2 I + R_3 I = I \cdot (R_1 + R_2 + R_3) \rightarrow \sum_{x=1}^{n} R_x = R$$

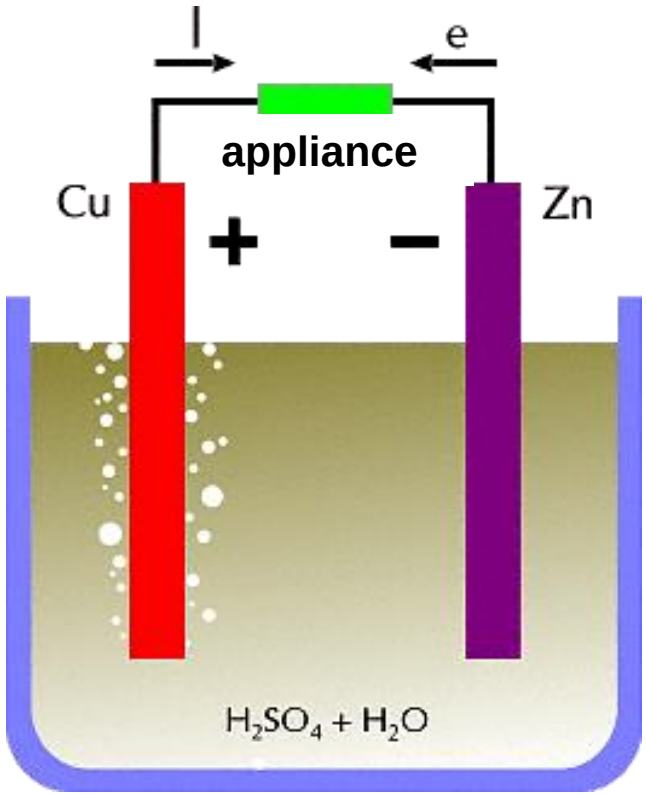
Resistors in parallel



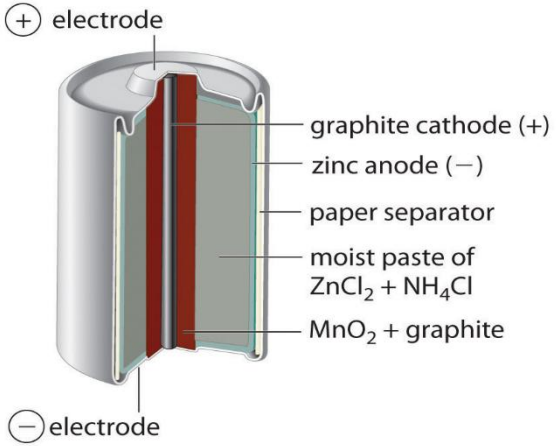
$$I = I_1 + I_2 + I_3 = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} = V \cdot \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right) \rightarrow \sum_{x=1}^{n} \frac{1}{R_x} = \frac{1}{R}$$

Voltage sources

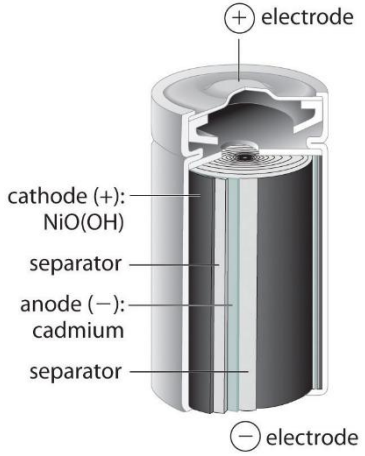
Wet galvanic cell



Non-rechargeable battery



Rechargeable battery



conversion of chemical energy into electrical energy

- **accumulator battery**



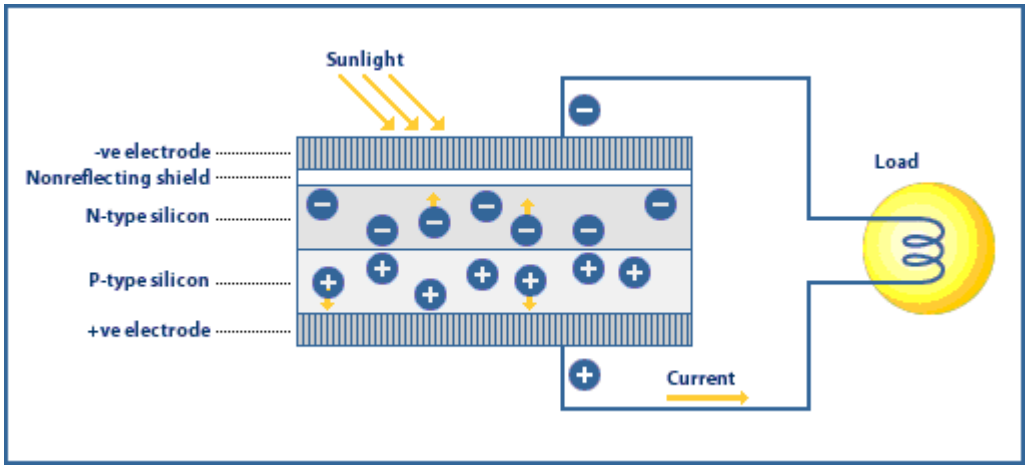
conversion of chemical energy into electrical energy

- **DC generator**



conversion of mechanical energy into electrical energy

- **photovoltaic cell**
- **solar panel**





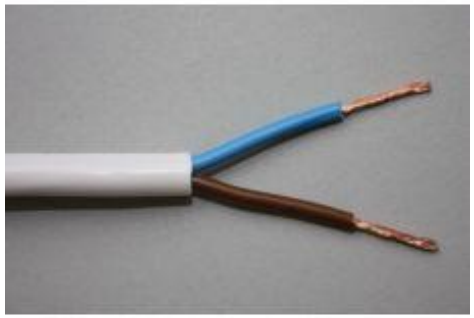
conversion of solar energy into electrical energy

Line (wires)

- good electrical conductivity
- economy
- mechanical ruggedness







Appliances and applications





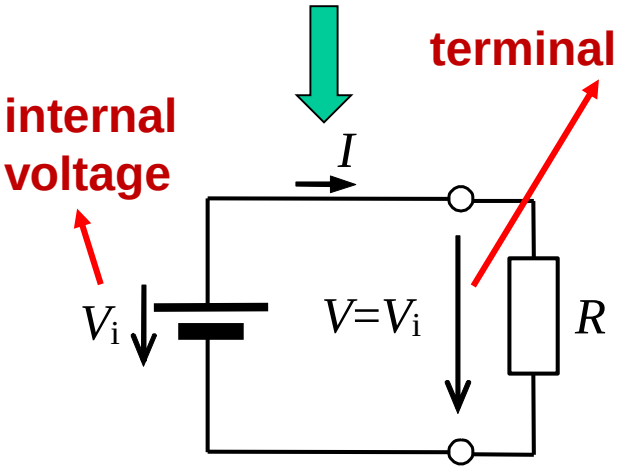




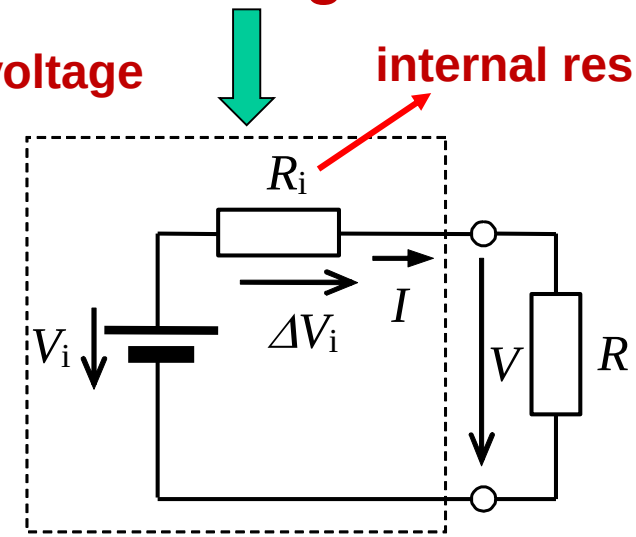


Characteristics and conditions of voltage sources

ideal voltage source



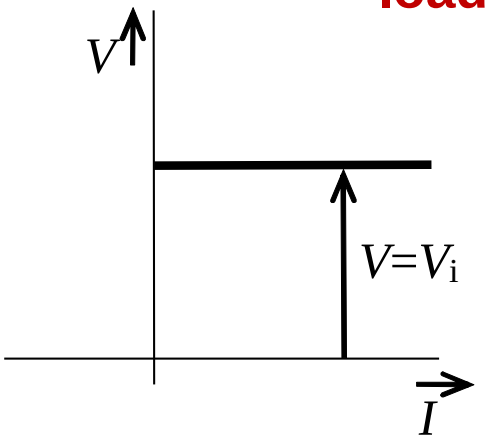
real voltage source

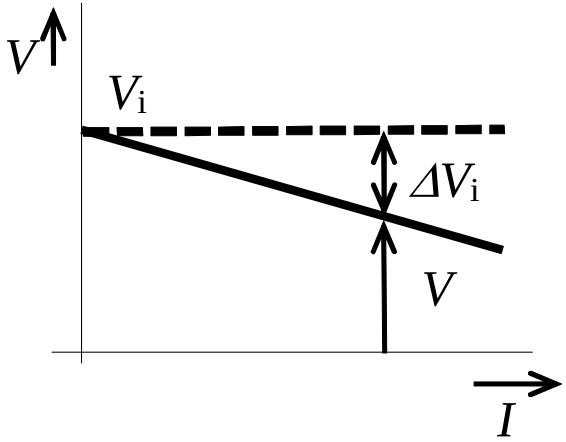


$$V = V_i - \Delta V_i = V_i - R_i \cdot I$$

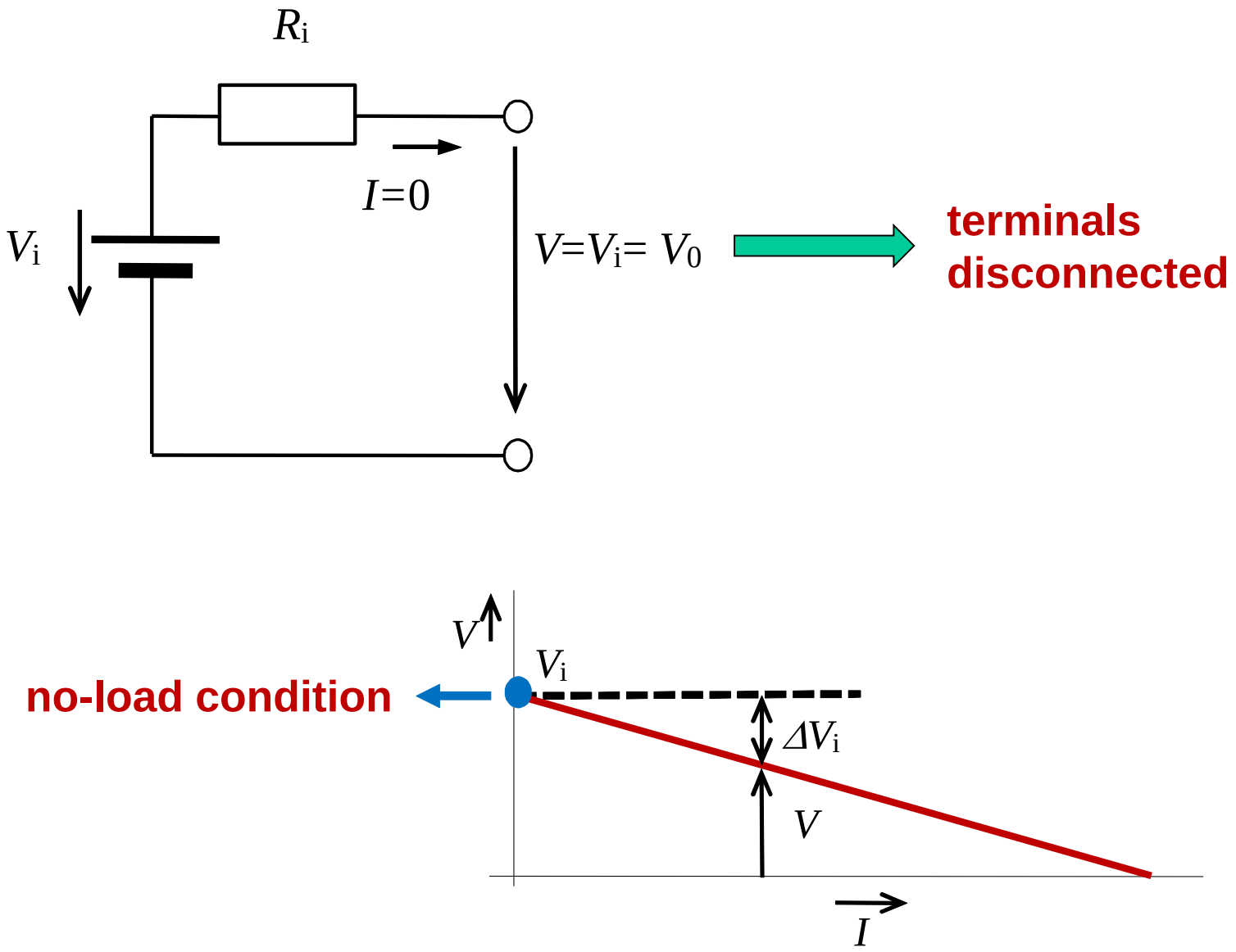
$$I = \frac{V_i}{R_i + R}$$

load characteristics

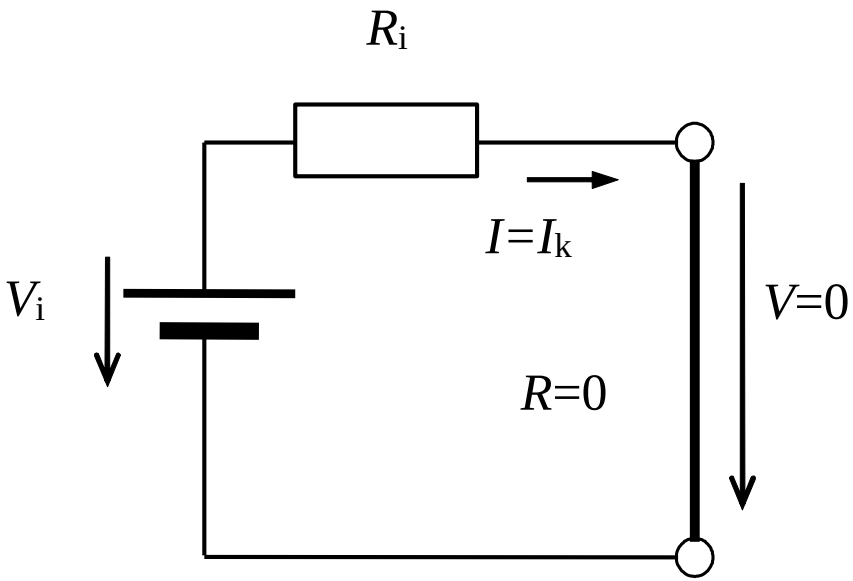




no-load condition



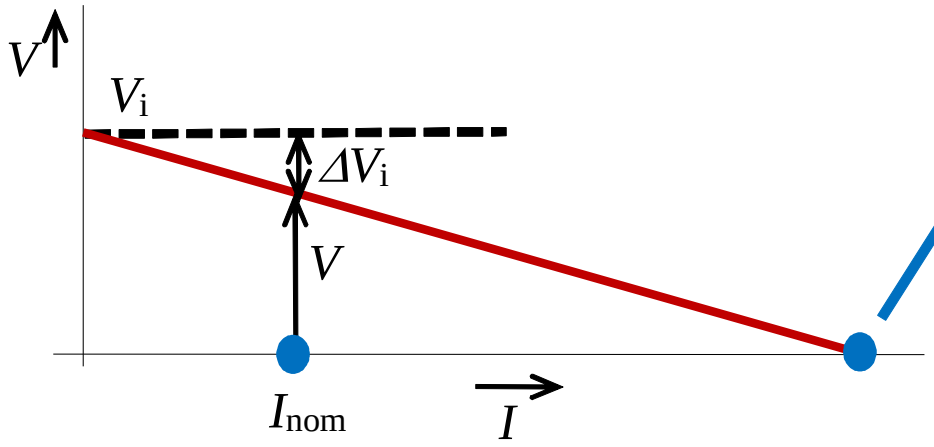
short-circuit condition



terminals short-circuited

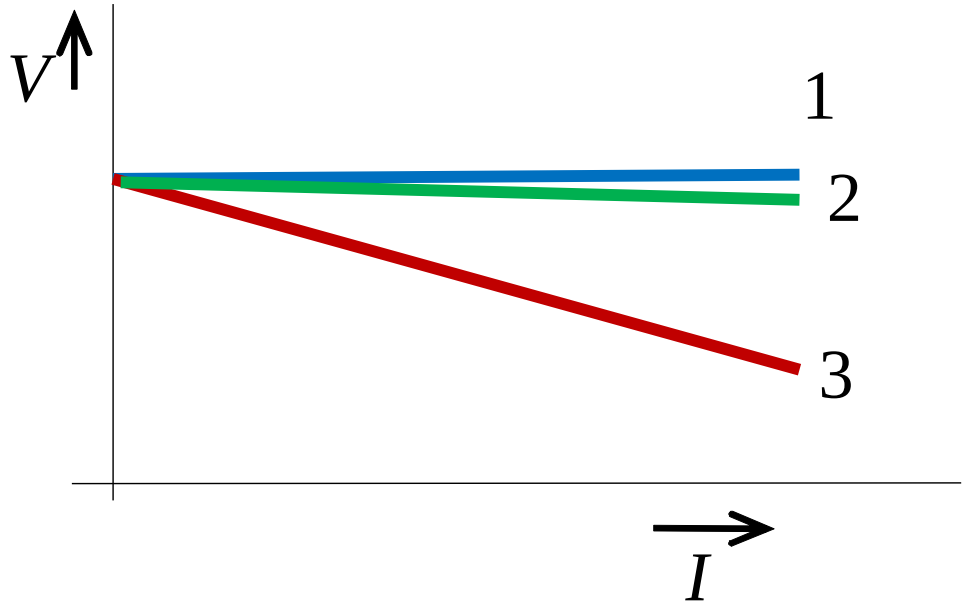
short-circuit current

$$I = I_k = \frac{V_i}{R_i}$$



$$I_k = (3 \div 20) \times I_{nom}$$

Types of voltage sources



1. Ideal voltage source: no internal resistance
2. Practical “hard” voltage source: low internal resistance
3. Practical “weak” voltage source: higher internal resistance