Summary

- The circuit elements introduced in this chapter are voltage sources, current sources, and resistors:
  - An **ideal voltage source** maintains a prescribed voltage regardless of the current in the device. An **ideal current source** maintains a prescribed current regardless of the voltage across the device. Voltage and current sources are either **independent**, that is, not influenced by any other current or voltage in the circuit; or **dependent**, that is, determined by some other current or voltage in the circuit. (See pages 48 and 49.)
  - A **resistor** constrains its voltage and current to be proportional to each other. The value of the proportional constant relating voltage and current in a resistor is called its **resistance** and is measured in ohms. (See page 52.)
- **Ohm's law** establishes the proportionality of voltage and current in a resistor. Specifically,

$$v = iR$$

if the current flow in the resistor is in the direction of the voltage drop across it, or

$$v = -iR$$

if the current flow in the resistor is in the direction of the voltage rise across it. (See page 53.)

- By combining the equation for power, $p = vi$, with Ohm's law, we can determine the power absorbed by a resistor:

$$p = i^2R = v^2/R.$$

(See page 54.)

- Circuits are described by nodes and closed paths. A **node** is a point where two or more circuit elements join. When just two elements connect to form a node, they are said to be **in series**. A **closed path** is a loop traced through connecting elements, starting and ending at the same node and encountering intermediate nodes only once each. (See pages 59–61.)
- The voltages and currents of interconnected circuit elements obey Kirchhoff's laws:
  - **Kirchhoff's current law** states that the algebraic sum of all the currents at any node in a circuit equals zero. (See page 59.)
  - **Kirchhoff's voltage law** states that the algebraic sum of all the voltages around any closed path in a circuit equals zero. (See page 60.)
- A circuit is solved when the voltage across and the current in every element have been determined. By combining an understanding of independent and dependent sources, Ohm's law, and Kirchhoff's laws, we can solve many simple circuits.

Five Basic Elements:

1. voltage sources
2. current sources
3. resistors
4. inductors
5. capacitators

2.1 Voltage & Current Sources

electric source: device that is capable of converting nonelectric energy to electric energy & vice versa

discharging/charging battery: chemical ↔ electric

dynamo: machine that converts mechanical & electrical energy

generator/motor: mechanical ↔ electric

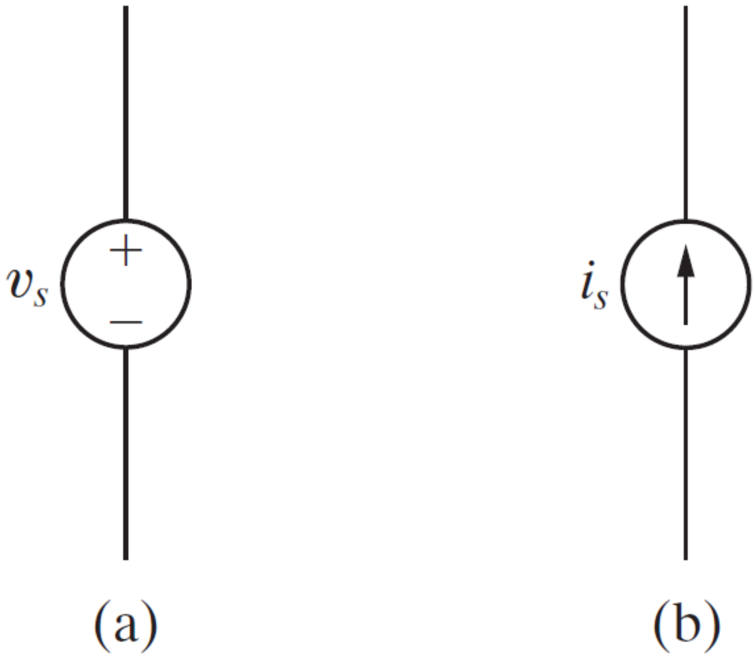
ideal* voltage source: circuit element that maintains a prescribed voltage across terminals regardless of current flowing through

ideal* current source: circuit element that maintains a prescribed current through terminals regardless of voltage across those terminals

*sacrificed ability to relate voltage & current in practical source for simplicity of using ideal sources in circuit analysis

independent source (a): establishes voltage/current in circuit w/o relying on voltages/currents elsewhere in circuit

dependent source (controlled source) (b): establishes a voltage/current whose value depends on value of voltage/ elsewhere. Cannot specify value unless that value of voltage/current is known.



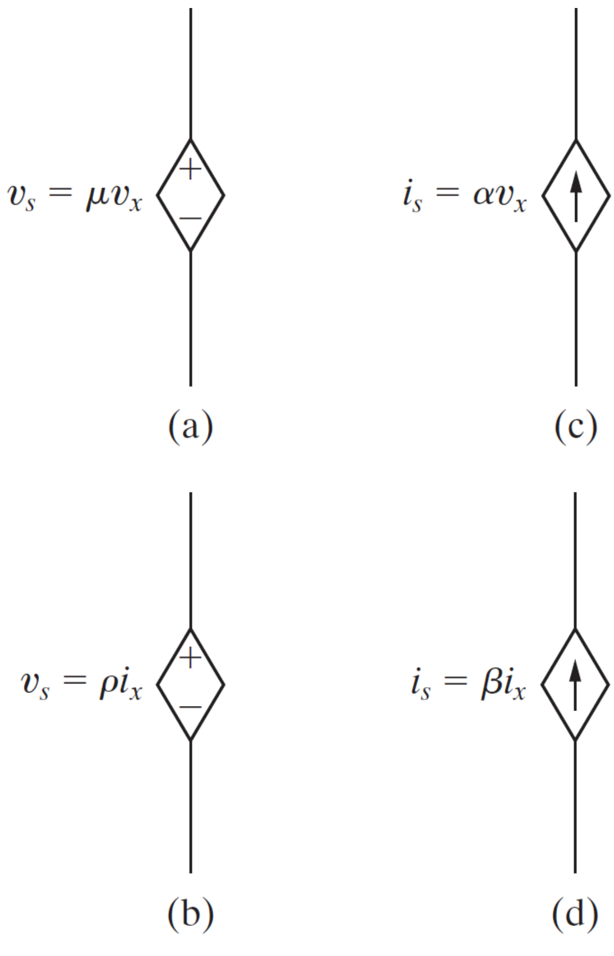


Figure 2.2 ▲ The circuit symbols for (a) an ideal dependent voltage-controlled voltage source, (b) an ideal dependent current-controlled voltage source, (c) an ideal dependent voltage-controlled current source, and (d) an ideal dependent current-controlled current source.

controlling voltage v_x and supplied voltage v_s:

$$v_s = \mu v_x \tag{2.1-1}$$

controlling voltage i_x and supplied voltage v_s:

$$v_s = \rho i_x \qquad (2.1\text{-}2)$$

controlling voltage v_x and supplied voltage i_s:

$$i_s = \alpha v_x \qquad (2.1\text{-}3)$$

controlling voltage i_x and supplied voltage i_s:

$$i_s = \beta i_x \qquad (2.1\text{-}4)$$

active element: models device capable of generating electric energy.

passive elements: models physical devices that cannot generate electric energy.

- resistors
- inductors
- capacitors

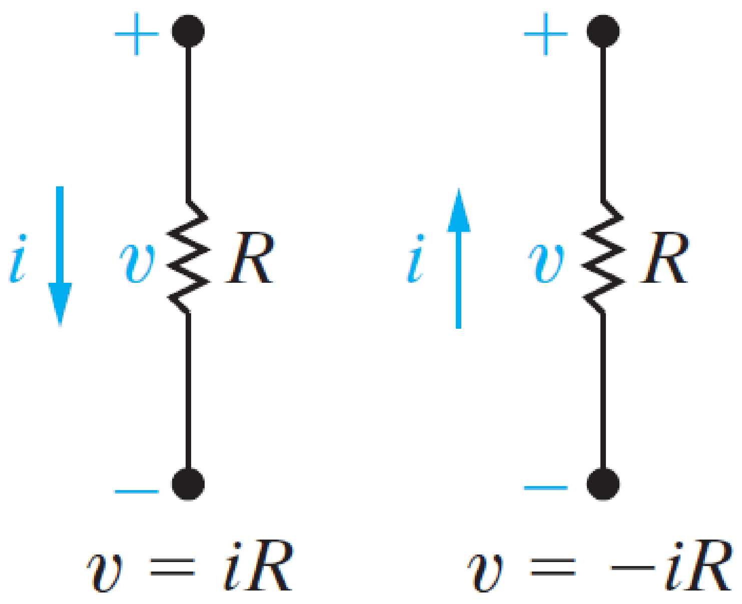
2.2 Electrical Resistance (Ohm's Law)

resistance: capacity of materials to impede flow of current (flow of electric charge) (Ω)

resistor: circuit element used to model resistance

Ohm's Law: algebraic relationship between voltage & current for a resistor

- positive/negative according whether voltage drops in resistor according to current direction



conductance: reciprocal of resistance; $G = \frac{1}{R} S$.

Power in a resistor:

$$p = i^2 R$$
$$p = \frac{v^2}{R}$$

2.3 Construction of Circuit Model

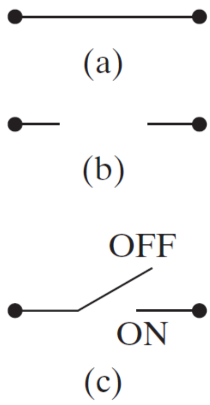


Figure 2.10 ▲ Circuit symbols. (a) Short circuit. (b) Open circuit. (c) Switch.

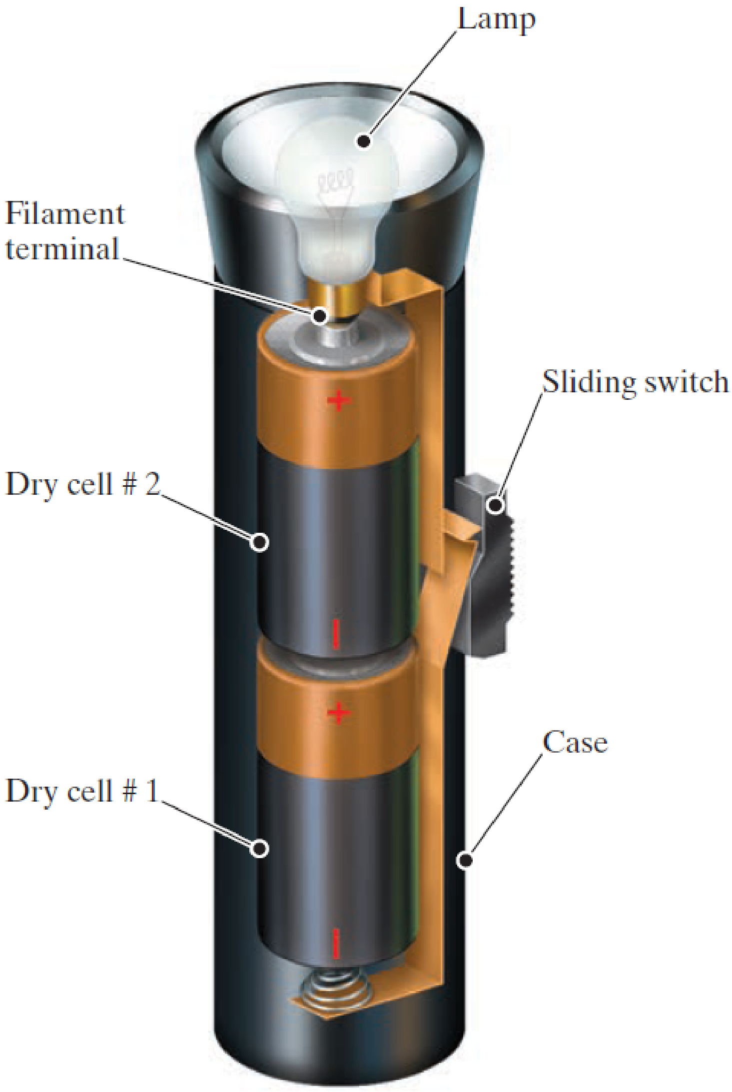


Figure 2.11 ▲ The arrangement of flashlight components.

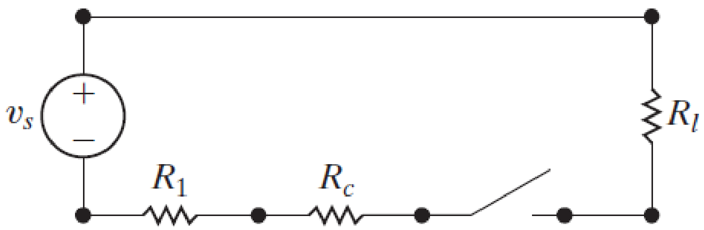
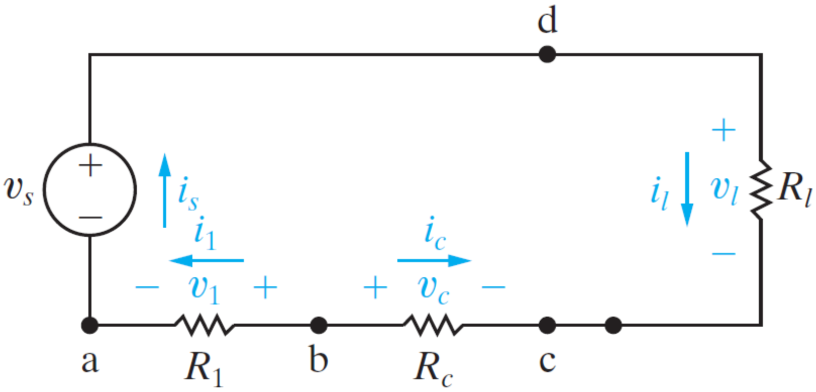


Figure 2.12 ▲ A circuit model for a flashlight.

2.4 Kirchhoff's Laws

circuit is solved when voltage across & current in every element have been determined

node: point where 2 or more circuit elements meet



7 unknowns:

- $i_s, i_1, i_c, i_l, v_1, v_c, v_l$

- v_s is a known voltage: sum of terminal voltages of 2 dry cells

Kirchhoff's Current Law (KCL): algebraic sum of all currents at any node in a circuit equals zero.

- $n - 1$ independent current equations can be derived
- must define closed path/loop

From Ohm's Law:

$$\begin{aligned} v_1 &= i_1 R_1 \\ v_c &= i_c R_c \\ v_1 &= i_1 R_1 \end{aligned}$$

From KCL:

$$\begin{aligned} i_s - i_1 &= 0 && \text{(node a)} \\ i_1 + i_c &= 0 && \text{(node b)} \\ -i_c - i_l &= 0 && \text{(node c)} \\ i_l - i_s &= 0 && \text{(node d)} \\ \text{Series, therefore: } i_s &= i_1 = -i_c = i_l \end{aligned}$$

Kirchhoff's Voltage Law (KVL): algebraic sum of all voltages around any closed path in circuit equals zero

$$v_l - v_c + v_1 - v_s = 0$$

in series: 2 elements connected at a single node

2.5 Analysis of a Circuit Containing Dependent Sources