EE40
Lecture 2
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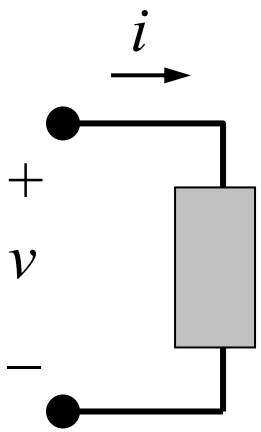
1/25/08

Reading: Chap. 1

The Ideal Basic Circuit Element



- Polarity reference for voltage can be indicated by plus and minus signs
- Reference direction for the current is indicated by an arrow

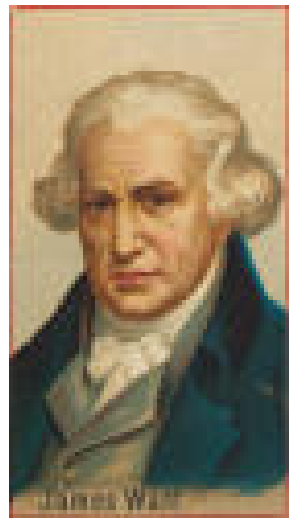
Attributes:

- Two terminals (points of connection)
- Mathematically described in terms of current and/or voltage
- Cannot be subdivided into other elements

Electric Power

- **Definition**: transfer of energy per unit time
- **Symbol**: p
- **Units**: Joules per second ≡ Watts (W)

$$p = dw/dt = (dw/dq)(dq/dt) = vi$$



James Watt
1736 - 1819

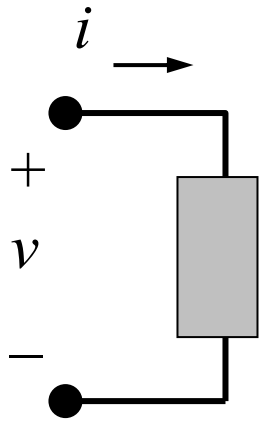
- **Concept**:

  As a positive charge q moves through a drop in voltage v, it loses energy

  - energy change = qv
  - rate is proportional to # charges/sec

Passive Sign Convention

$$p = vi$$

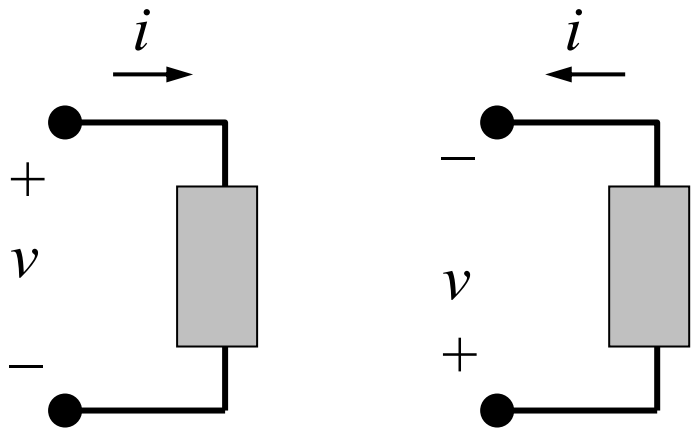


- If p > 0, power is being delivered to the box.
  - The element is a passive element.
- If p < 0, power is being generated from the box.
  - The element is an active element.
- How can a circuit element absorb power?
  - By converting electrical energy into heat (resistors in toasters), light (light bulbs), or acoustic energy (speakers); by storing energy (charging a battery).

Sign Convention for Power

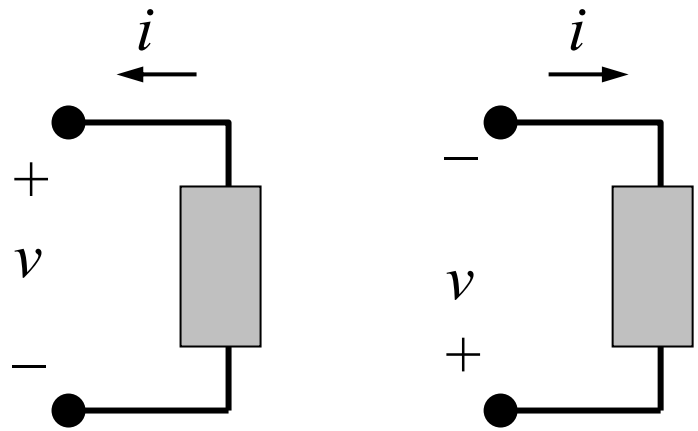
Passive sign convention

$$p = vi$$



Active sign convention

$$p = -vi$$



Irrespective of the sign convention

- If $p > 0$, power is being delivered to the box.
- If $p < 0$, power is being extracted from the box.

Electrical Resistance

- ***Resistance:*** the ratio of voltage drop and current. The circuit element used to model this behavior is the ***resistor***.

Circuit symbol:

Units: Volts per Ampere ≡ ohms (Ω)

Georg Simon Ohm
1789-1854

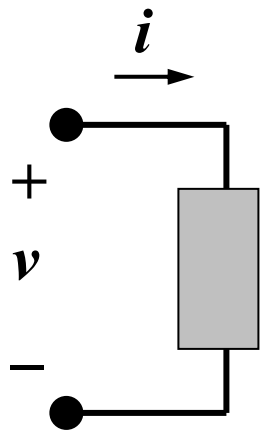
- The current flowing in the resistor is proportional to the voltage across the resistor:

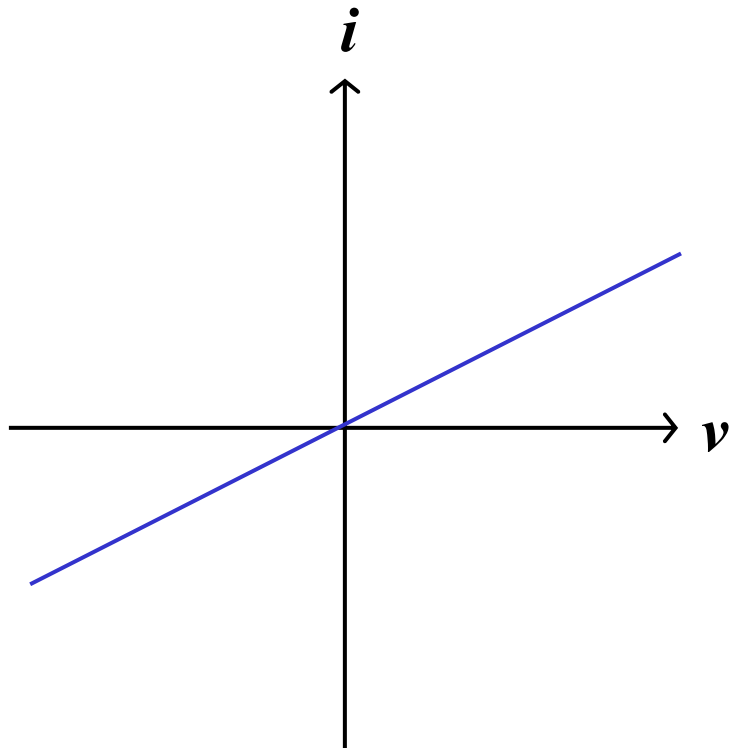
$$v = i\,R \quad \text{(Ohm's Law)}$$

where v = voltage (V), i = current (A), and R = resistance (Ω)

Current *vs.* Voltage (*I-V*) Characteristic

What is the *I-V* characteristic for an ideal resistor?





The slope must be positive and the characteristic must go through the origin.

Electrical Conductance

- **Conductance** is the reciprocal of resistance.

  Symbol: G

  Units: **siemens (S) or mhos (℧)**

  Example:

  Consider an 8 Ω resistor. *What is its conductance?*

Werner von Siemens
1816-1892

Electrical Sources

- An ***electrical source*** is a device that is capable of converting non-electric energy to electric energy and *vice versa*.

  Examples:

  – battery: chemical ⟷ electric

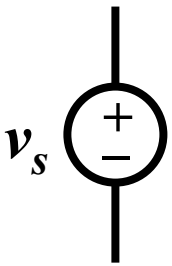
  – dynamo (generator/motor): mechanical ⟷ electric
    (Ex. gasoline-powered generator, Bonneville dam)

→Electrical sources can either deliver or absorb power

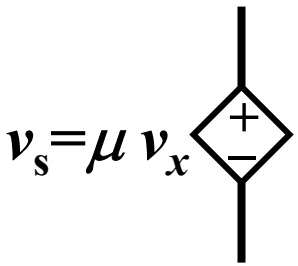
Ideal Voltage Source

- Circuit element that maintains a prescribed voltage across its terminals, **regardless of the current flowing in those terminals**.
  - Voltage is known, but current is determined by the circuit to which the source is connected.
- The voltage can be either **independent** or **dependent** on a voltage or current elsewhere in the circuit, and can be constant or time-varying.

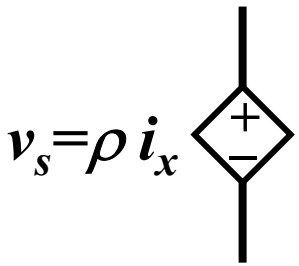
Device symbols:



independent

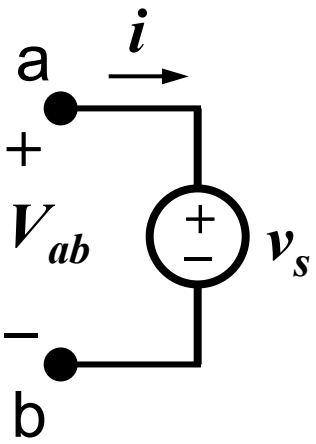


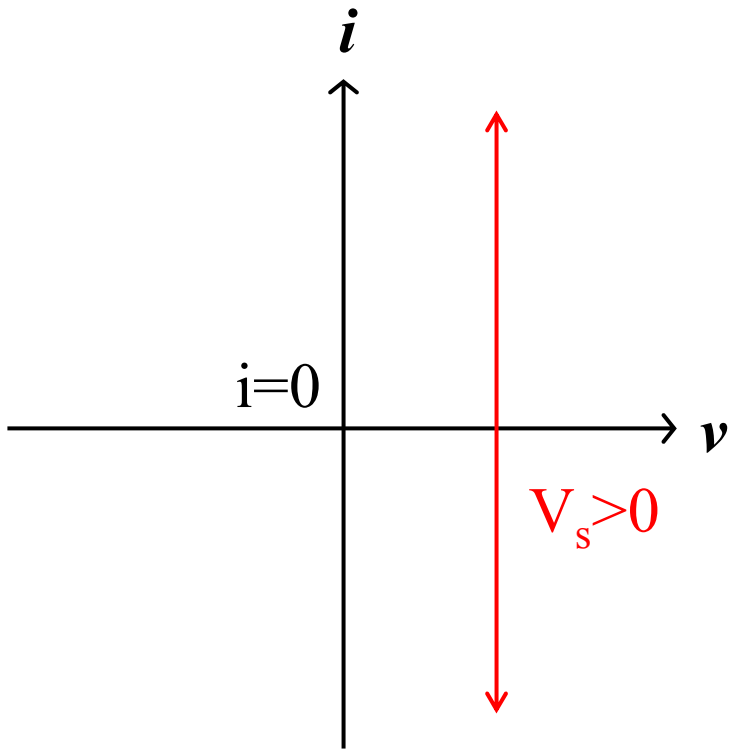
voltage-controlled



current-controlled

I-V Characteristic of Ideal Voltage Source





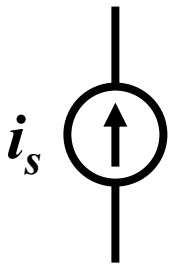
1. **Plot the *I-V* characteristic for $v_s > 0$. For what values of *i* does the source absorb power? For what values of *i* does the source release power?**

V_s>0 → i<0 release power; i>0 absorb power

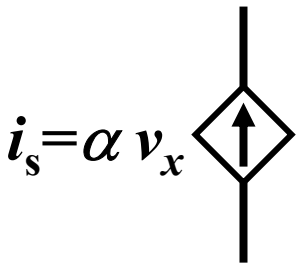
Ideal Current Source

- Circuit element that maintains a prescribed current through its terminals, **regardless of the voltage across those terminals**.
  - Current is known, but voltage is determined by the circuit to which the source is connected.
- The current can be either **independent or dependent** on a voltage or current elsewhere in the circuit, and can be constant or time-varying.

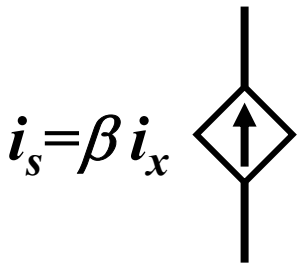
Device symbols:



independent

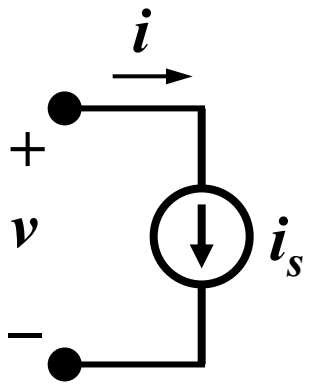


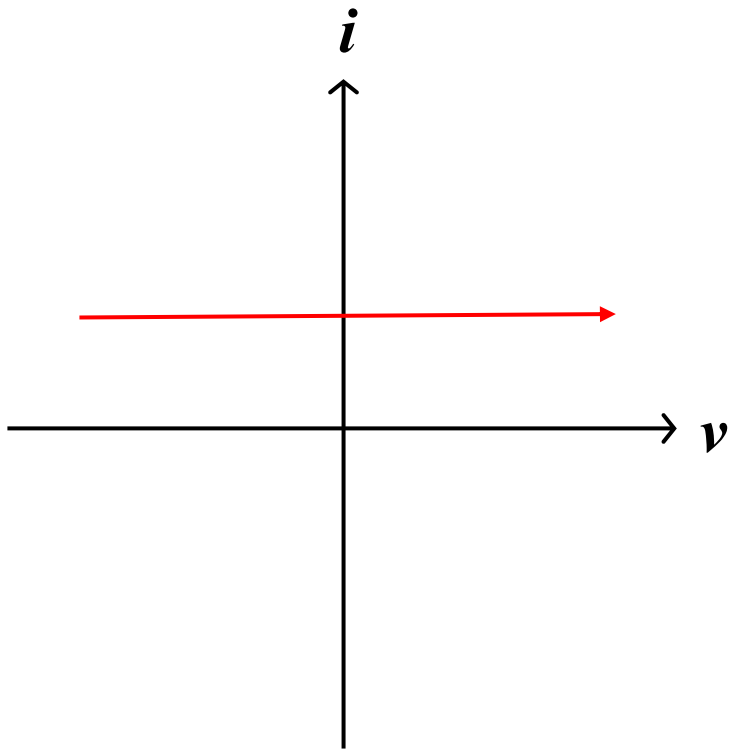
voltage-controlled



current-controlled

I-V Characteristic of Ideal Current Source





1. **Plot the *I-V* characteristic for $i_s > 0$. For what values of v does the source absorb power? For what values of v does the source release power?**

   V>0 absorb power; V<0 release power