Electrical Quantities, Circuit Elements, KCL

EE40, Summer 2004

Alessandro Pinto
apinto@eecs.berkeley.edu

Announcements

- ✓ **New schedule** has been posted on-line
- ✓ **Office hours** moved in 463 Cory Hall
- ✓ No discussions no labs this week!
- ✓ Would you **move lectures** in 247 Cory Hall?
- ✓ **HW** will be posted on Friday and will be due by 5PM in 463 Cory Hall the following friday

About Labs

010	10
012	3
013	27
014	3
015	13

$\longrightarrow$

010	18
013	19
015	19

Missing e-mail addresses

name [BAN, IL HYUN]

name [BAZARRAGCHAA, ZORIGT]

name [BESTORY, CORINNE]

name [BROWNING, JASON]

name [CHUNG, HYE WON]

name [JANG, WEON WI]

name [JWA, TAI WOOK]

name [KIM, JU HYUN]

name [KIM, KI SANG]

name [LEEPER, ANDREW ALAN]

name [LIM, SANG HO]

name [NORONA, CHARLES EDWARD]

name [RYU, SEONG WAN]

neilg@uclink.berkeley.edu

psyrex@uclink4.berkeley.edu

Outline

- ✓ Basic quantities
  - ✓ Charge
  - ✓ Current
  - ✓ Voltage
  - ✓ Power
- ✓ Basic elements
  - ✓ Resistor
  - ✓ Voltage Source
  - ✓ Current Source
  - ✓ Capacitor
  - ✓ Inductor
- ✓ Kirchoff's Current Law

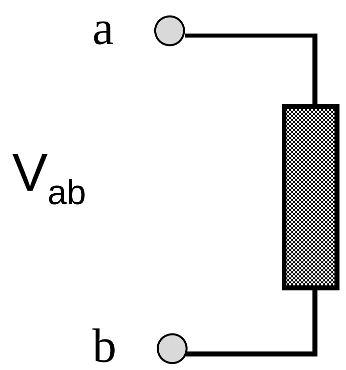
Charge

- Charge are quantized
  - Multiple of $1.602 \cdot 10^{-19}$ *Coulomb*
- Charge conservation principle
  - Electric charge is neither created nor destroyed
- Rubbing amber and fur separates charges but the system is still neutral

Voltage

- ✓ Work done per unit charge to move against an electric field

$$v = \frac{dw}{dq}$$

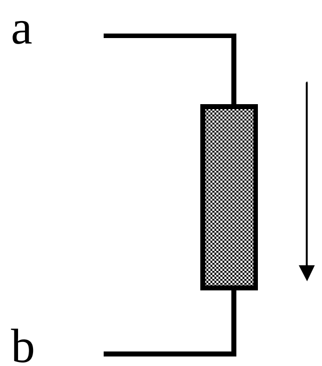


$$v_{ab} = v_a - v_b$$

- ✓ Remember that voltage is defined with respect to a reference point
- ✓ Unit of measure Volt (V) = Joule/Coulomb (in honor of Alessandro Volta)

Current

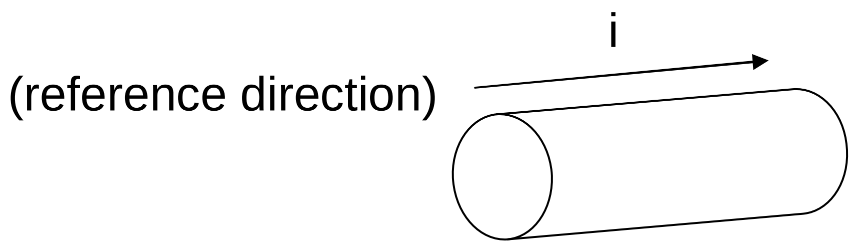
- ✓Rate of flow of electric charge



$$i = \frac{dq}{dt} \quad \left[\frac{Coulomb}{\sec} = Ampere \right]$$

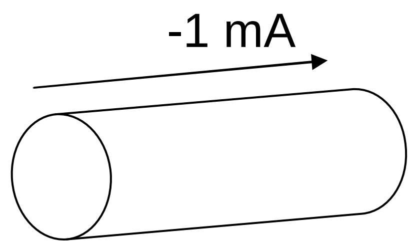
- ✓Unit of measure Ampere (A) (in honor of André-Marie Ampère)
- ✓Current has polarity and direction

Reference direction



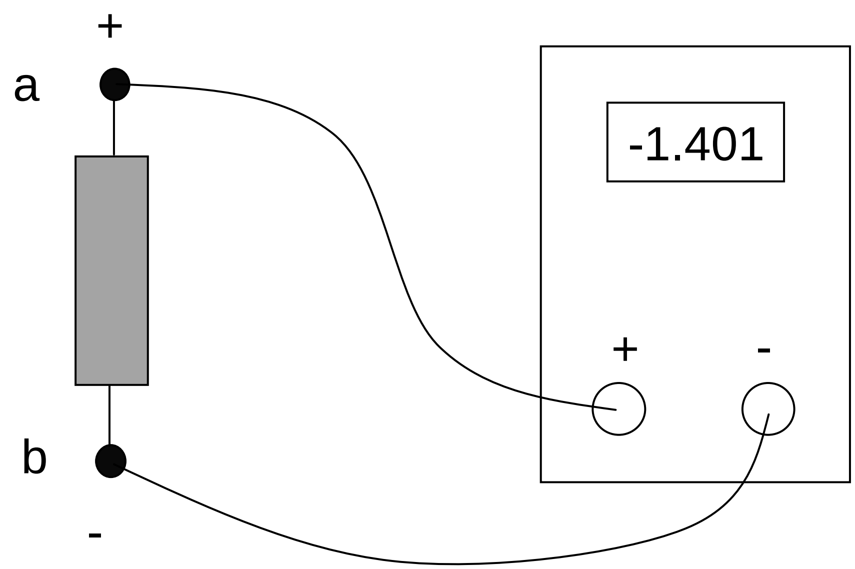
- ✓ Count charges flowing in the conductor
  - ✓ Positive charges flowing in the reference direction contribute as positive
  - ✓ Positive charges flowing against the reference direction contribute as negative
  - ✓ Negative charges flowing in the reference direction contribute as negative
  - ✓ Negative charges.......

Reference direction



✓It means that there is a flow of 1 mC of positive charges per second **against the reference direction**

Reference Polarities



$$v_{ab} = v_a - v_b = -1.401$$

$$v_{ba} = v_b - v_a = 1.401$$

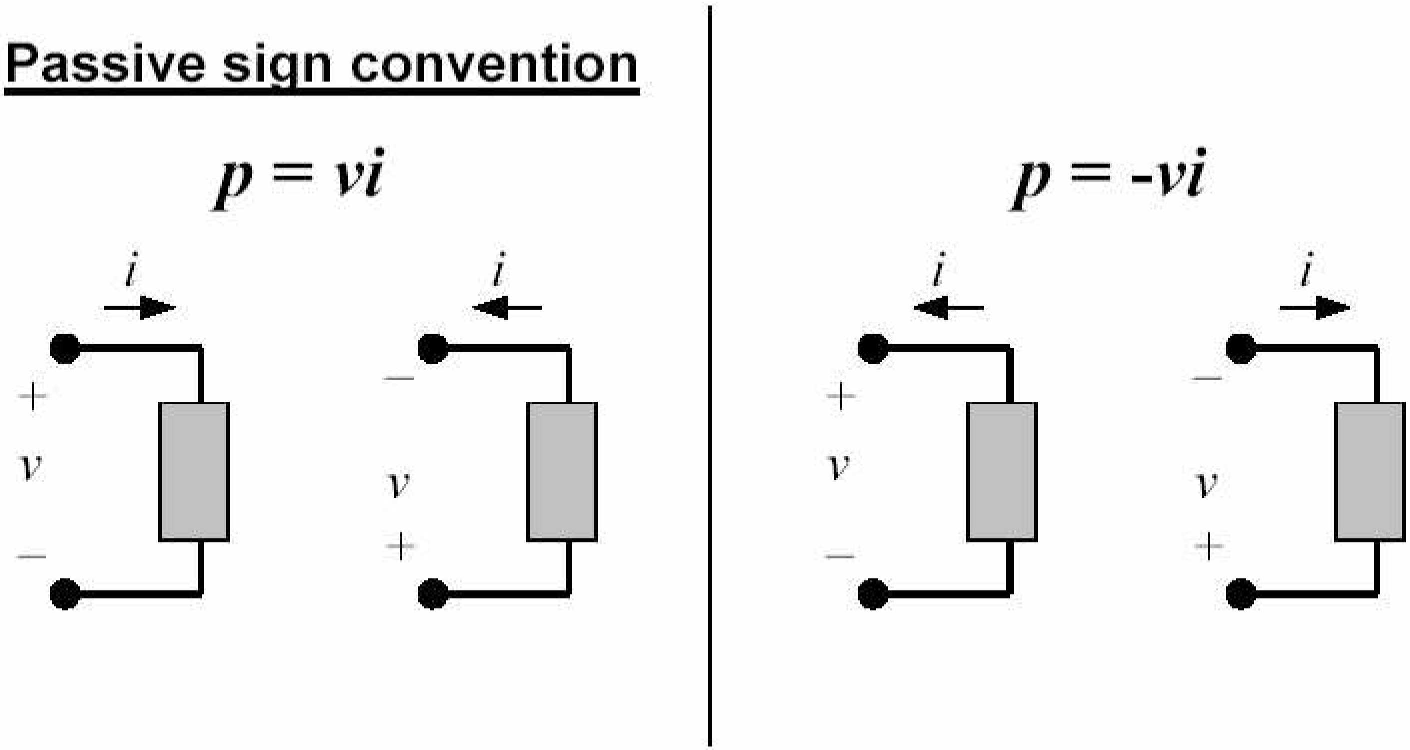
Power

- ✓Change in energy over time

$$p=\frac{dw}{dt}=\frac{dw}{dq}\frac{dq}{dt}=vi \quad [Volt \cdot Ampere = Watt]$$

- ✓A charge q moving through a drop in voltage V loses energy qV
- ✓Rate of energy loss depends on number of charges per second, which is current

Sign Convention for Power

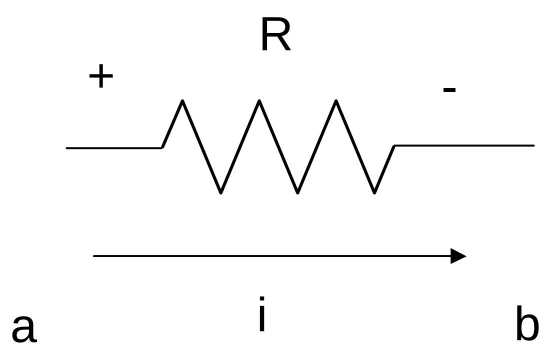


- If $p > 0$, power is being delivered to the box.
- If $p < 0$, power is being extracted from the box.

Resistor

Resistance is the capacity of a material to impede the flow of electric charge. The circuit element used to model this behavior is the ***resistor***.

With the reference direction and polarities shown we get the Ohm's law

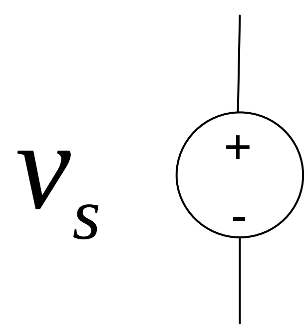


$$v_{ab} = Ri \;\; [V = \Omega \; A]$$

A resistor always absorb power,
R is always positive

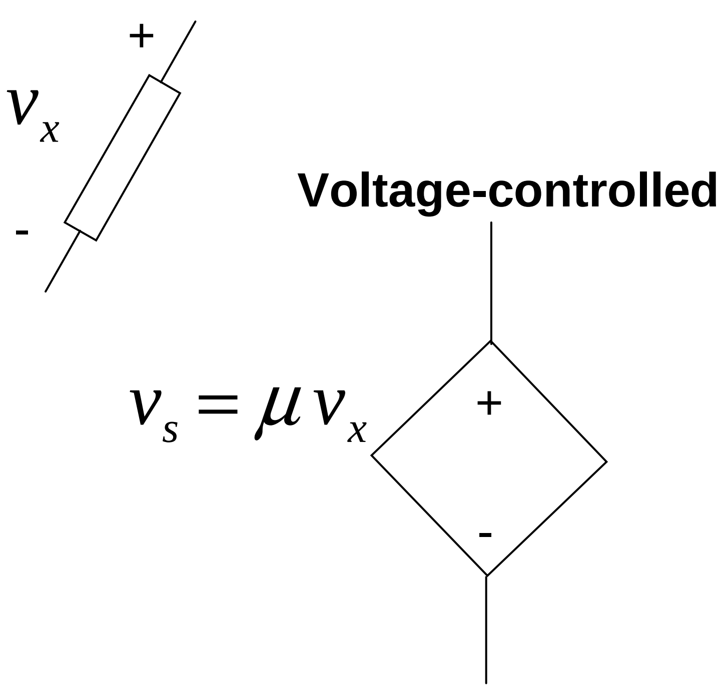
Voltage Sources

- **Independent 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.

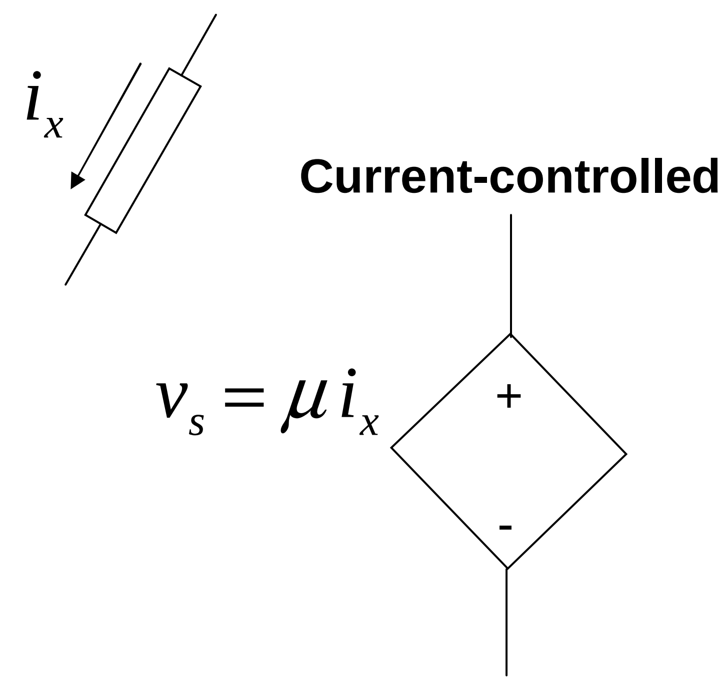


Voltage Sources

- ✓ **<u>Dependent ideal voltage source</u>**
  - ✓ It is a voltage source whose voltage depends on a voltage or current elsewhere in the circuit



$$v_s = \mu v_x$$

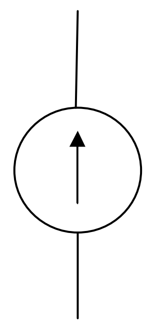


$$v_s = \mu i_x$$

Current Sources

- ✓ **Independent 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.

i_s



Current Sources

- ✓ **<u>Dependent ideal current source</u>**
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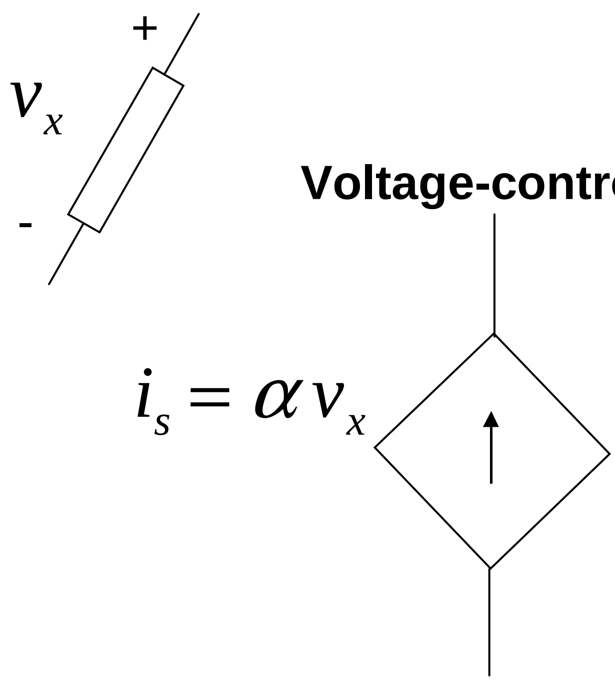
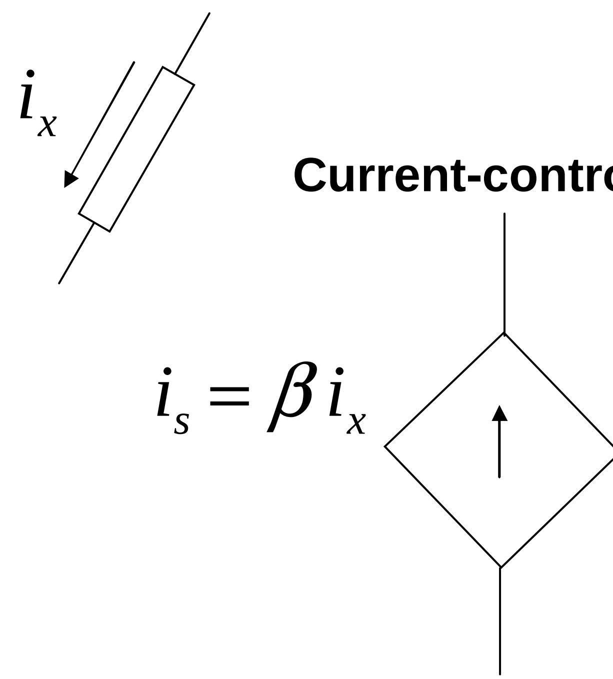
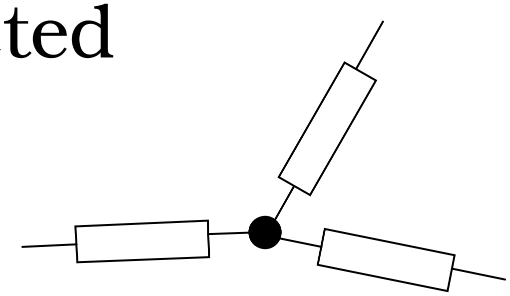




Circuit Nodes and Loop

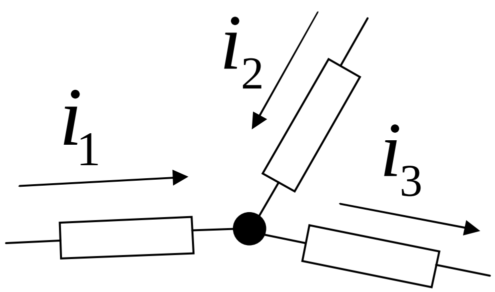
- ✓ A node is a point where two or more circuit elements are connected



- ✓ A loop is a path of circuit elements that starts and ends at the same node and includes other nodes at most once

Kirchoff's Current Law

- ✓The algebraic sum of all the currents at any node in a circuit equals zero.
- ✓The sum of all currents entering a node is equal to the sum of all currents leaving a node



$$i_1 + i_2 - i_3 = 0$$

$$i_1 + i_2 = i_3$$