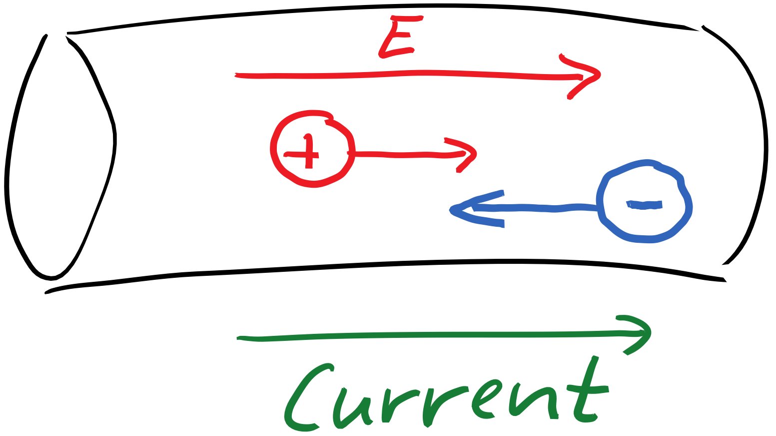
Review:
Current, Resistance, Ohm’s Law

Direction of current

- Current is motion of charges
- Charge carriers in metals are electrons
- Current is created by a potential difference due to an electric field

$$I = \frac{\Delta q}{\Delta t}$$



Unit: 1C/1s= 1A   Ampere

Resistance and resistivity

Current increases proportional to applied voltage

Ohm's Law $I = \frac{\Delta V}{R}$

$R = \frac{\Delta V}{I}$ Resistance

Unit: 1V/1A= 1Ω Ohm

Resistance depends on:

- Material
- Length of wire
- Cross section

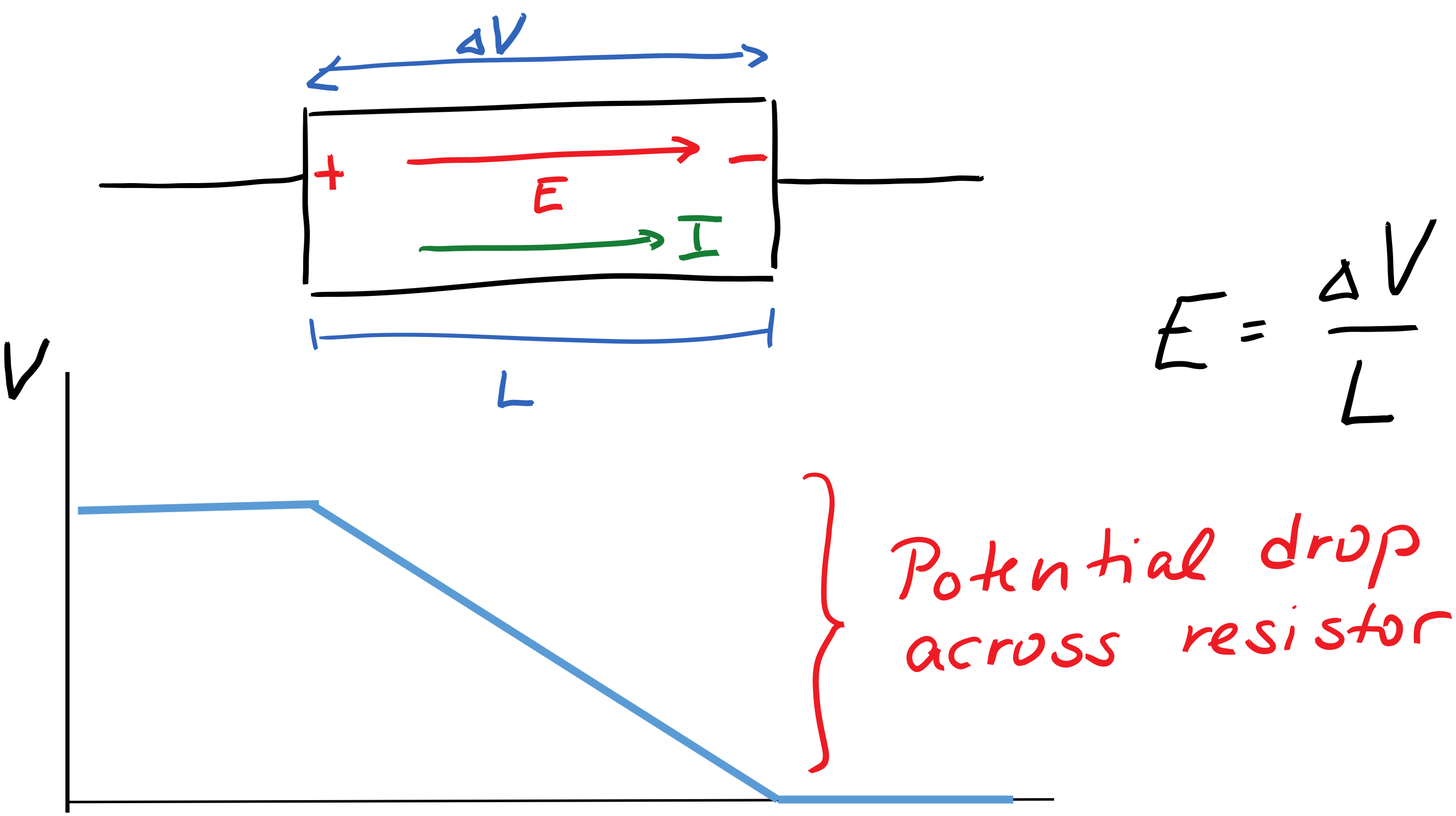
Resistance is a device property.

$R = \frac{\rho L}{A}$

ρ resistivity (lower case Greek "rho")
Unit: Ωm
Material property

Current flow through resistor

Assume "ideal wires" (R=0).



Power

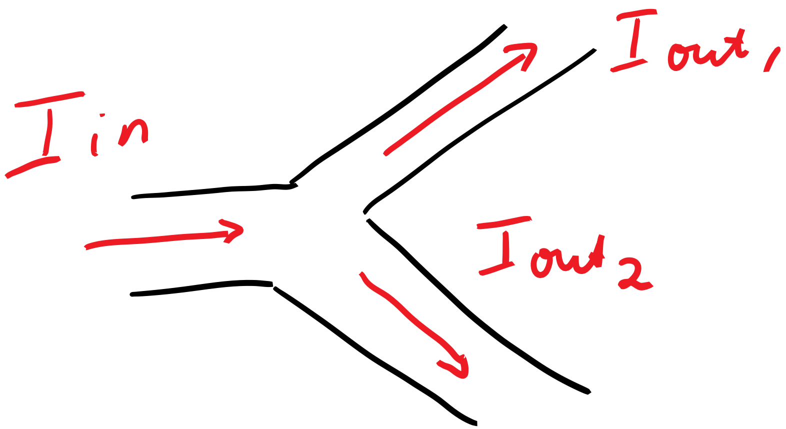
When current flows through a resistor, power is dissipated and energy transformed into heat.

$$P_R = I\Delta V_R = I^2 R = \frac{(\Delta V_R)^2}{R}$$

Kirchhoff's Laws: Junction Law

Current is the same at all points in a current-carrying wire.

Current is not "used up". Charge cannot be created or destroyed.
"What goes in must come out".

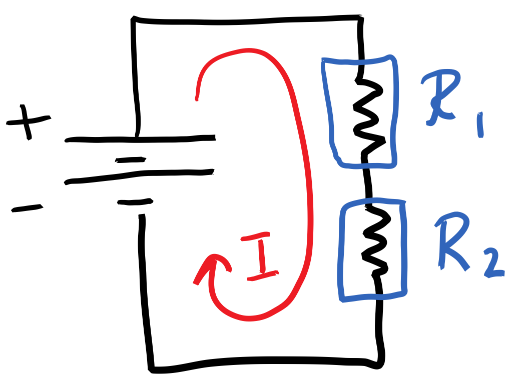


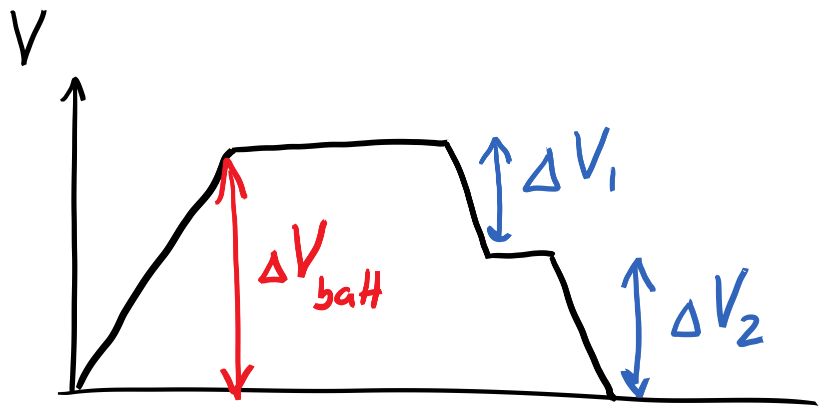
$$\sum I_{in} = \sum I_{out}$$

Kirchhoff's Laws: Loop Law

Potential energy depends on position.
If we come back to the same point, we come back to the same value of potential energy.

$$\Delta V_{loop} = \sum_i \Delta V_i = 0$$





Resistors in series

Same current

$$R_{eq} = \sum R_i$$

Resistors in parallel

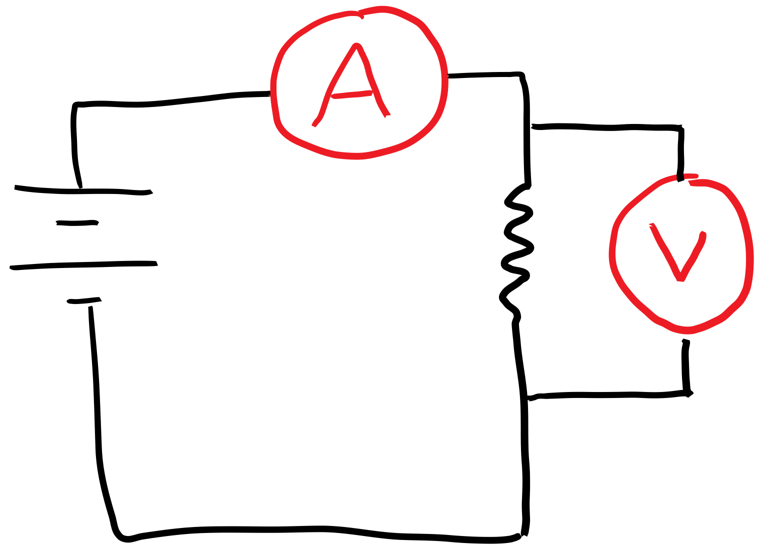
Same voltage

$$\frac{1}{R_{eq}} = \sum \frac{1}{R_i}$$

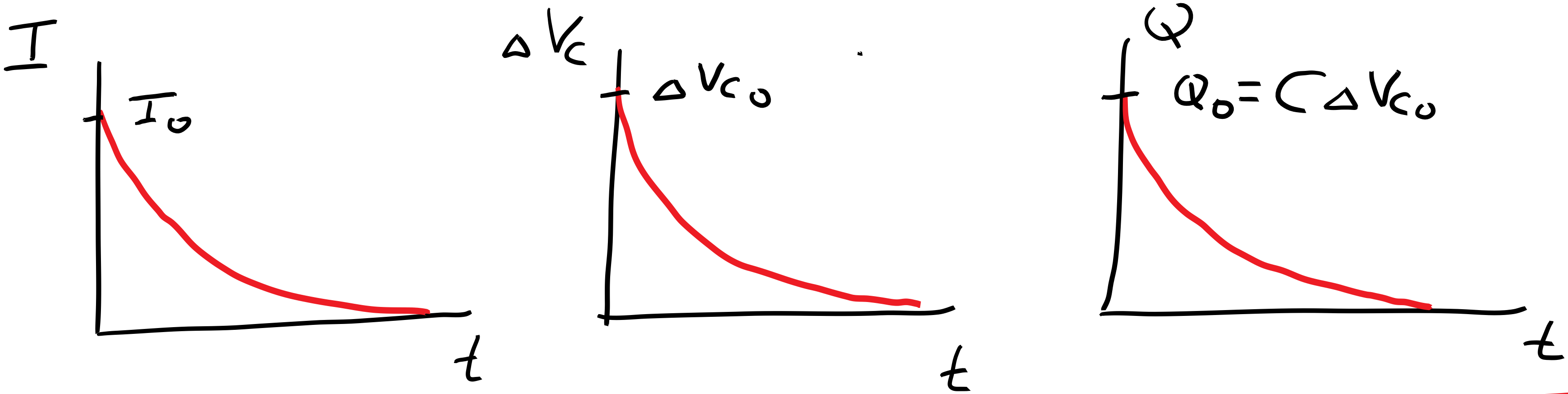
Measuring current and voltage

- Voltmeter in parallel with the resistor (same voltage)
- Ideal Voltmeter: infinite resistance

- Ammeter in series with the resistor (same current)
- Ideal Ammeter: zero resistance



Discharging a capacitor



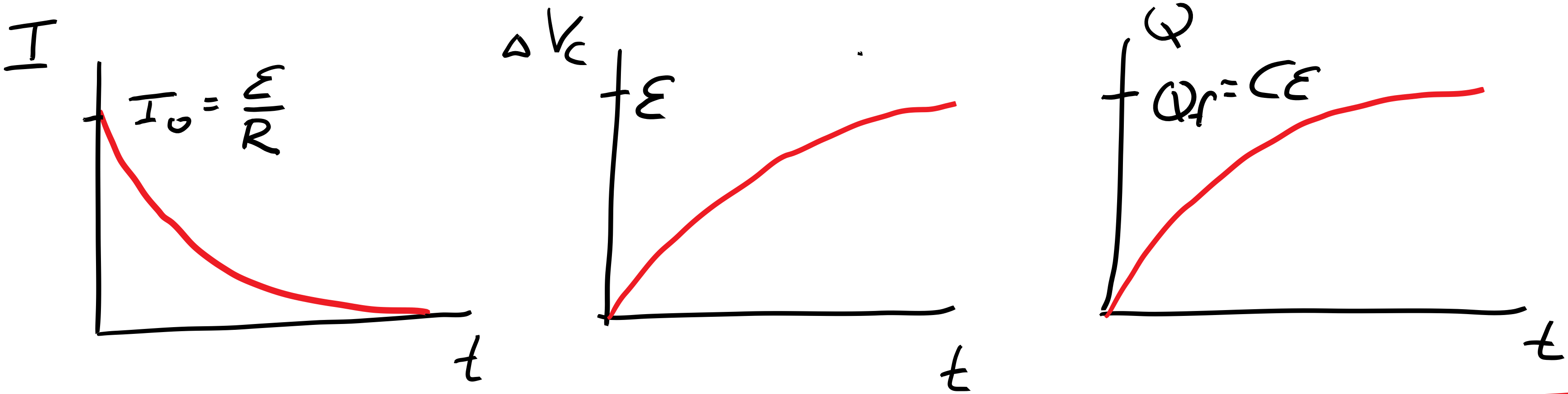
$$I = I_0 e^{-\frac{t}{RC}}$$

$$\Delta V_c = \Delta V_{c_0} e^{-t/RC}$$

$$Q = Q_0 e^{-t/RC}$$

$\tau = RC$ time constant

Charging a capacitor



$$I = I_0 e^{-\frac{t}{RC}}$$

$$\Delta V_c = \varepsilon\left(1 - e^{-t/RC}\right)$$

$$Q = Q_f\left(1 - e^{-\frac{t}{RC}}\right)$$

$\tau = RC$ time constant