CHAPTER 19:

REVIEW

Electric current

$$I = \frac{|Q|}{\Delta t}$$

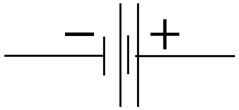
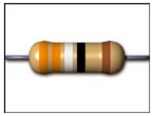
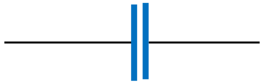
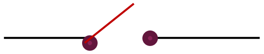
Unit: $ampere$

Ampere is a basic SI unit (like meter, kilogram, and second).

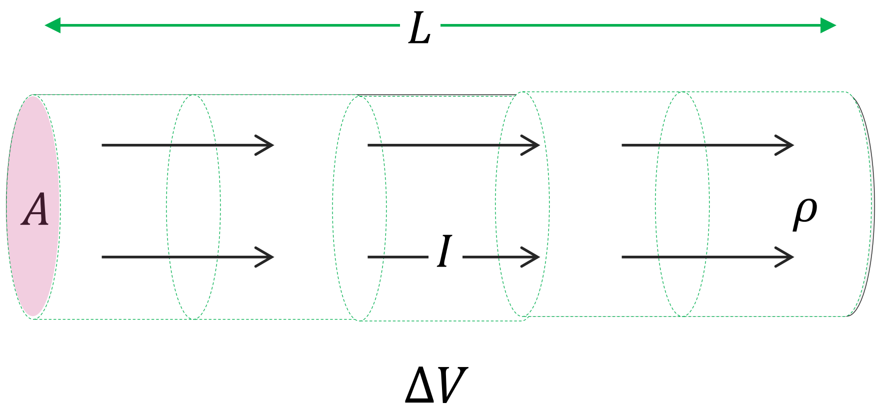
A coulomb is defined as: $1\mathrm{C} = 1\mathrm{A} \cdot 1s$

https://phet.colorado.edu/sims/html/circuit-construction-kit-ac/latest/circuit-construction-kit-ac_en.html

19.3 Circuit Elements and Diagrams

Element	Picture	Symbol
Battery		
Wire		
Resistor		
Bulb		
Junction		
Capacitor		
Switch		

19.4 RESISTANCE AND OHM'S LAW



A – cross section of the wire
L – length of the wire
ρ – resistivity of the material
ΔV – potential difference between the ends of the wire
I – current in the wire

Current in the conductor is proportional to the potential difference between the ends of the conductor.

The proportionality constant is called **RESISTANCE** and for a conductor it is defined to be:

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

Units of the resistance: $1\text{ohm} = 1\Omega = \frac{1V}{1A}$

Current through the conductor can be written as $I = \frac{\Delta V}{R}$

Resistivity

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

Material	Resistivity (Ωm)	Conductivity $(\Omega^{-1}\text{m}^{-1})$
Aluminum	2.8×10^{-8}	3.5×10^{7}
Copper	1.7×10^{-8}	6.0×10^{7}
Gold	2.4×10^{-8}	4.1×10^{7}
Iron	9.7×10^{-8}	1.0×10^{7}
Silver	1.6×10^{-8}	6.2×10^{7}
Tungsten	5.6×10^{-8}	1.8×10^{7}
Nichrome	1.5×10^{-8}	6.7×10^{5}
Carbon	3.5×10^{-5}	2.9×10^{4}

Resistivity ρ tells us how reluctantly the charges move in response to an electric field.

It is a property of the material (like density) and is measured in Ωm.

Ohmic Materials

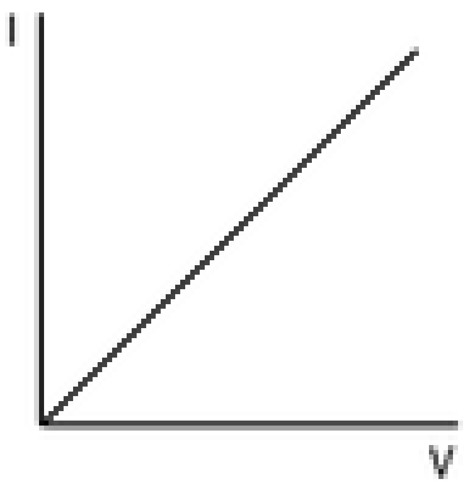
We identify three kinds of ohmic materials:

a) wires (ideal, $R = 0$)
b) resistors
c) insulators (ideal, $R = \infty$)

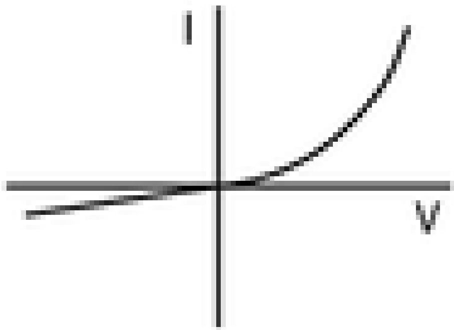
Non-ohmic materials, $I = \frac{\Delta V}{R}$ but only at given time.

Ohmic material, $I \propto V$ through the entire range

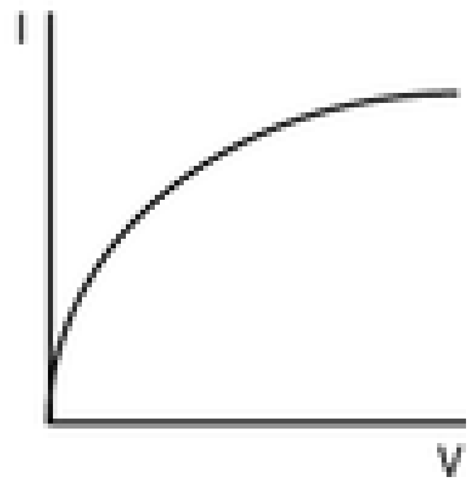
Resistance changes due to other factors.



Metallic conductor



Semiconductor diode



Filament lamp

RESISTANCE AND RESISTIVITY

If we apply the same potential difference between the ends of geometrically similar materials, we will get various results.

The characteristic of a conductor that plays part here is **resistance.**

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

The SI units: 1 $ohm = 1\Omega = 1\ volt\ per\ ampere$

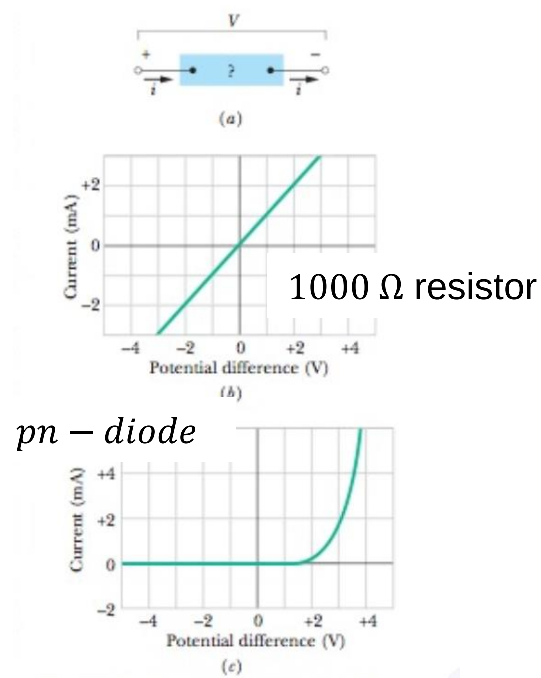
A conductor, whose function in a circuit is to provide specific resistance is a **resistor.**

Resistivity of the material defined as

$$\rho = \frac{E}{J}.$$

(in vectorial form $\vec{E} = \rho\vec{J}$)

Conductivity $\sigma = \frac{1}{\rho}$

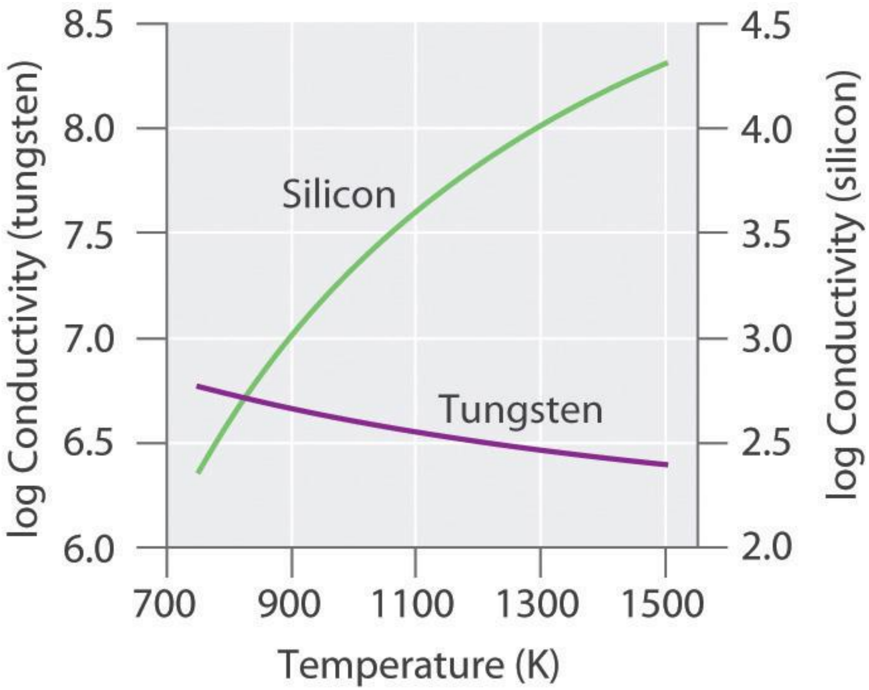


Resistance is a property of an **object**.
Resistivity is a property of a ***material***.

VARIATION OF TEMPERATURE

Resistivity is a function of temperature. The empirical (first order) approximation equation that works for most application is

$$\rho = \rho_0\left(1 + \alpha(T - T_0)\right)$$



Graph above: log of conductivity as a function of temperature for Si and W.

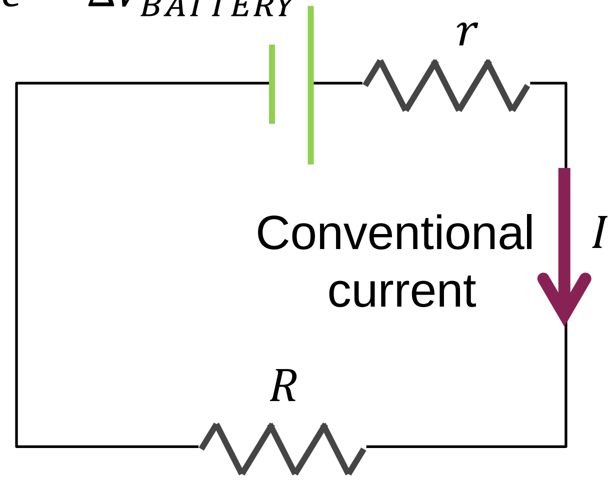
Single Loop Circuits

EMF (ϵ) - "*electromotive force*" – the energy per unit charge that is converted reversibly from chemical, mechanical or other forms of energy into electrical energy in a battery or dynamo.

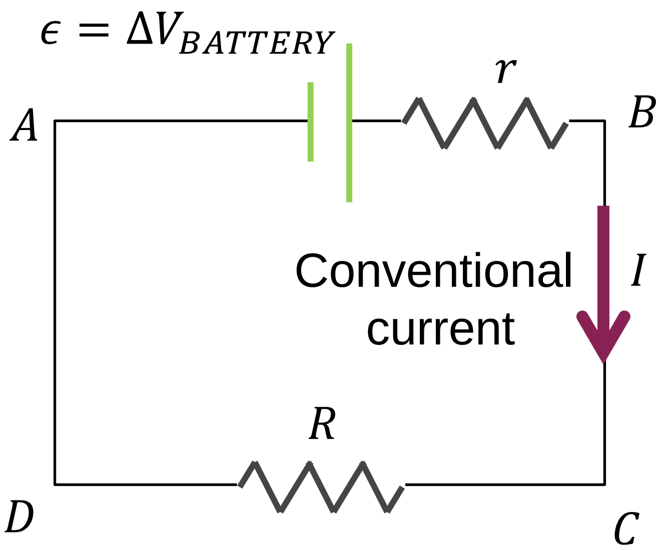
Consider a circuit consisting of a battery connected to a resistor. Assume connecting wires have no resistance.

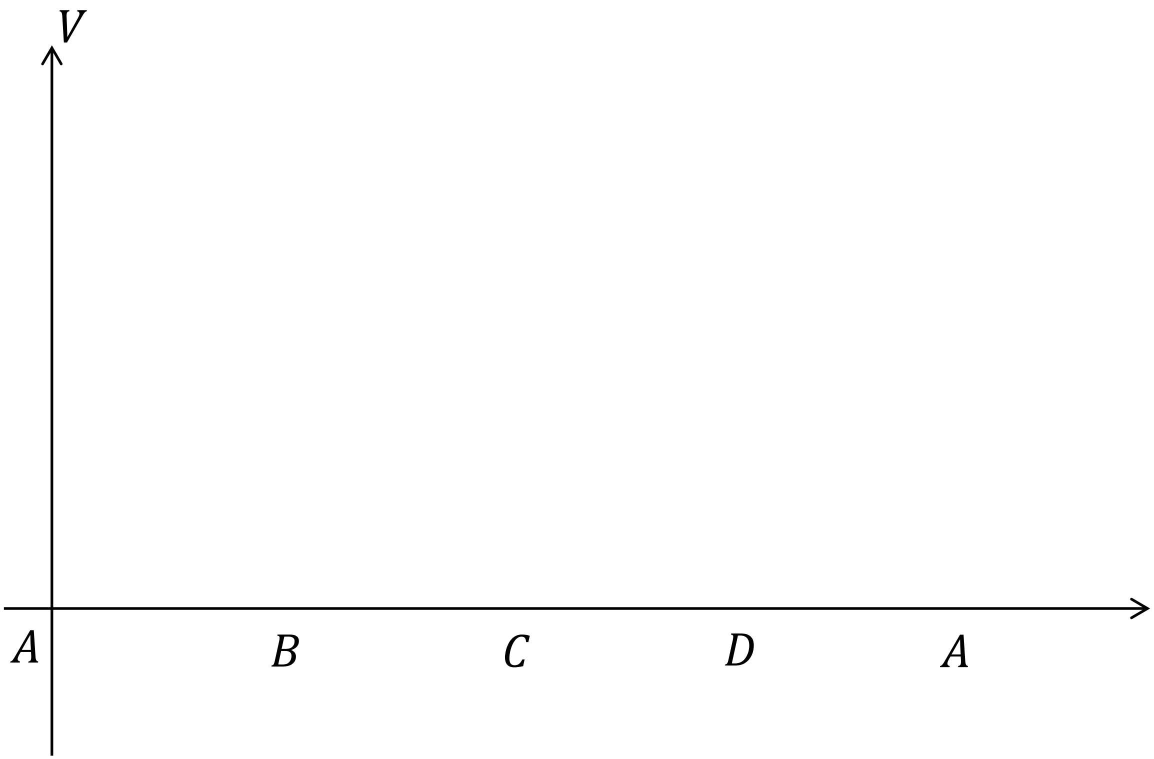
Real batteries have **internal resistance** r. As a result, the voltage provided is not equal to the *emf.*

$\epsilon = \Delta V_{BATTERY}$



The terminal voltage of the battery:





Solving for current:

The internal resistance of a functioning battery is typically small (a few thousands of an ohm for a new car battery) but its effect is not negligible.