Linear Circuits

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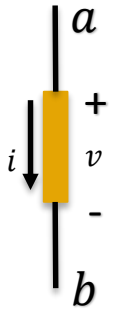
Resistance and Ohm's Law

Objectives: By the end of this lesson, you should understand the resistance property of materials as well as the relationship between resistance, current, and voltage.

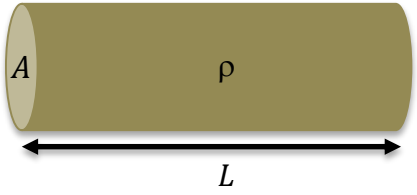
Builds Upon

- Electric current (i) - the quantity of charge that passes through a given area in a specified time.

- Voltage (V) - the energy either gained or lost per coulomb of charge.



Resistance and Resistivity

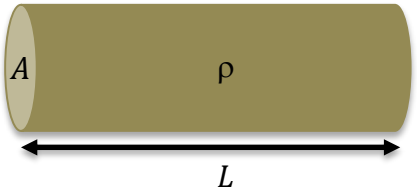


$$\rho_{metals} = 10^{-8}\ to\ 10^{-3}\ \Omega m$$
$$\rho_{rubber} = 10^{5}\ to\ 10^{15}\ \Omega m$$

- When charged particles flow through a material, they encounter electrical resistance (R).
- Electrical resistance is determined by the material's cross sectional area (A), length (L), and resistivity (ρ).
- The resistivity is an intrinsic property that quantifies the material's opposition to charge flow.
- Variable: R
- Unit: $\frac{V}{A}, \Omega, ohms$

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

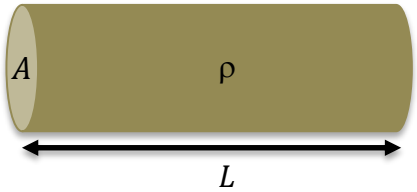
Conductance and Conductivity



- Electrical conductance measures how a material allows charge flow.
- Conductance (G) is the reciprocal of resistance.
- The conductivity (σ) is an intrinsic property that quantifies the material's receptiveness to charge flow. Conductivity is the reciprocal of resistivity.
- Variable for conductance: G
- Unit: $\frac{A}{V}, siemens, or\ \mho,\ mhos$

- $\mathrm{G} = \frac{1}{R} = \frac{\sigma A}{L}$
- $\sigma = \frac{1}{\rho}$

Calculate resistance and conductance.



- Quiz: A $1\ m$ long copper wire of area $0.001\ m^2$. The copper's resistivity is $2 \times 10^{-8} \Omega m$. Find the resistance the wire.

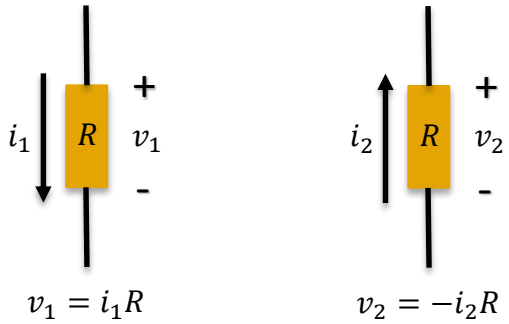
- Quiz: If the wire's area doubles, how do the resistivity and the conductivity change?

Ohms Law

- Charged particles flow through a material and encounter electrical resistance.

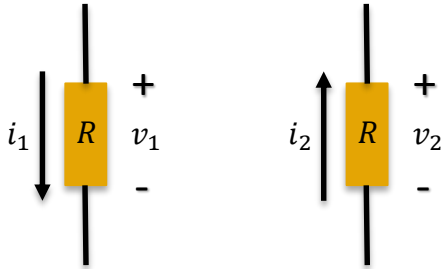
- The voltage (V) produced by the current flow (i) is proportional to the resistance (R) of that material.

- Ohm's Law: $V = iR$



$v_1 = i_1 R$ $\quad$ $v_2 = -i_2 R$

Apply Ohm's Law



$R = 2k\Omega$
$v_1 = -6V$

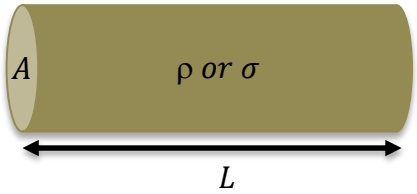
$R = 4k\Omega$
$i_2 = 6mA$

- Quiz: Find i_1.

- Quiz: Find v_2.

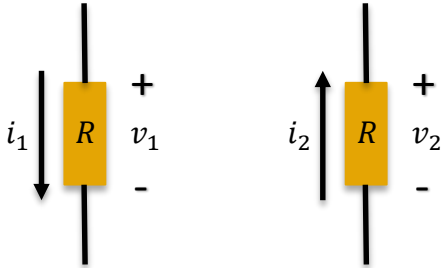
Key Concepts

- Electrical resistance and conductance are determined by a material's cross sectional area, length, and resistivity.



$$R = \frac{\rho L}{A} \quad G = \frac{\sigma A}{L}$$

- Ohm's Law: $V = iR$



$v_1 = i_1 R$ $\quad$ $v_2 = -i_2 R$