Ohm's Law

Current caused by electric field in conductor

Amount of current depends on
- Strength of field
- How conductive the conductor is

$$\vec{J} = \sigma\vec{E}$$

σ is electrical conductivity

Ohm's Law

$$\vec{J} = \sigma\vec{E}$$

σ is electrical conductivity

Alternatively written as

$$\vec{J} = \frac{1}{\rho}\vec{E}$$

ρ is electrical resistivity

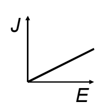
Either version may be referred to as Ohm's Law

(In this context, σ and ρ are NOT charge densities.)

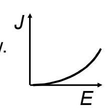
Ohm's Law

$$\vec{J} = \frac{1}{\rho}\vec{E}$$

Some materials follow Ohm's Law.
Ohmic materials



Other materials do not follow Ohm's Law.
Non-Ohmic materials



(Ohm's Law is not a Law of Nature.)

Example: A 4.0m long 12-guage wire carries a current of 2.86A when connected across a potential difference of 0.055V. [12-guage wire has a diameter of 2.053mm.]
a) Determine the current density in the wire.
b) Determine the resistivity of the wire.
c) Determine the electric field in the wire.

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Find a material of which the wire could be made.

Material	Conductivity ($\times 10^7$ /Ωm)	Resistivity ($\times 10^{-8}$ Ωm)	Temperature Coefficient (/°C)
Aluminum	3.77	2.65	0.00429
Gold	4.1	2.44	0.0034
Copper	5.95	1.68	0.00386
Silver	6.29	1.59	0.0038

Silicon*	1.56×10^{-3} /Ωm	6.4×10^{2} Ωm	-0.075 /°C

*Silicon values depend strongly on impurities.

Ohm's Law

$$\vec{J} = \frac{1}{\rho}\vec{E}$$

Resistivity depends on temperature.

$$\rho = \rho_0[1 + \alpha(T - T_0)]$$

α is the temperature coefficient and ρ_0 is the resistivity at T_0.

Example: A wire at $20℃$ is connected to a power supply yielding an initial current through the wire of 0.080A. The wire heats up to $260℃$, at which the current through the wire is 0.04A. Determine the temperature coefficient of the material.

Microscopic vs. Macroscopic View

Microscopic
- Material
- Resistivity
- Current Density

$$\vec{E} = \rho\vec{J}$$

Macroscopic
- Device
- Resistance
- Current

$$V = IR$$

Connections

$$J = \frac{I}{A} \qquad R = \rho\frac{L}{A}$$