RESISTANCE

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

$$J = I/A$$

If the field in the wire is uniform

$$V = \int E_{\parallel} ds = El$$

$$E = V/l$$

Subst. above

$$E = \rho J \Rightarrow V/l = \rho (I/A)$$

or

$$V = I \left(\frac{\rho l}{A} \right)$$

We define a characteristic of the wire, or element, the RESISTANCE

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

$$\boxed{V = IR \quad \text{Ohm's law}}$$

Units

$$1\, V A^{-1} = 1\, \Omega \text{ ohm}$$

Recall 10 gauge wire has $d = 2.95\,mm$

$$R = \rho \, l / A$$

use <u>bigger</u> wire for lower resistance
<u>shorter</u> wire for lower resistance

3 gauge #'s is difference of 1.4 in diameter ⇒ factor of 2 in area
(7 gauge is twice as much area as 10 gauge)

1 meter length of copper wire #10

$$\rho = 1.72 \times 10^{-8}\ \Omega m$$

$$A = \pi r^2 = 3.14 \cdot \left(\frac{2.95}{2}\right)^2 = 6.83 \times 10^{-4} m^2$$

$$R = 1.72 \times 10^{-8}\ \Omega m \cdot 1m / 6.83 \times 10^{-4} m^2$$

$$= 2.52 \times 10^{-3}\ \Omega$$

@ 115 V (household voltage)

$$V = IR \qquad I = V/R = \frac{115\,V}{2.52 \times 10^{-3}\ \Omega}$$

$$= 4.57 \times 10^4\, A$$

$$J = \frac{I}{A} = \frac{4.5 \times 10^4}{6.8 \times 10^{-4} m^2} = 6.72 \times 10^9\ A/m^2$$

$$E = \rho J = 116\ V/m$$

Pure resistance

$$P = VI \Rightarrow \boxed{P = I^2 R = V^2/R}$$
$$V = IR \qquad I^2 = V^2/R^2$$

Energy dissipated in going through resistance R. Collisions of electrons transfer energy to lattice ⇒ conductor heats up, convert energy in $\vec{E}$ field to KE of electrons (current) to heat energy in resistor. Our light bulb

$$P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{(115\,V)^2}{100\,W}$$

$$R = 132\ \Omega$$

P.D. V causes current to flow through filament of light bulb. Resistance of filament is set so that power consumption = 100 W. (e.g. we know ρ of tungsten make A + l such that 115 V ⇒ P = 100 W)

Current flowing through resistance of filament dissipates energy in form of heating bulb + emission of light