Current & Ohm’s Law

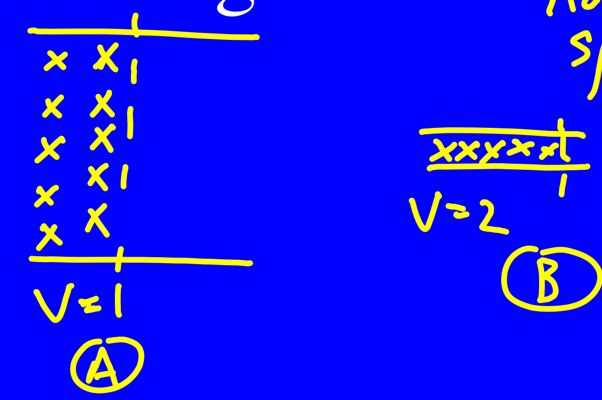
"But what...is it good for?"-- Engineer at the Advanced Computing Systems Division of IBM commenting on the microchip, 1968.

"There is no reason anyone would want a computer in their home." Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977

Current

- When charge flows a current exists.
- Current is the rate at which charge flows through a cross-sectional area.

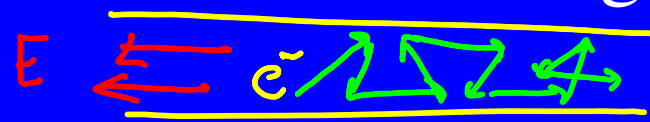
rate not speed



- **$I = dQ/dt$** (units are $\frac{C}{s}$ = amps A)
- Conventional current is the direction of positive charge flow.
- The moving charge (normally an electron) are often referred to a mobile charge carriers.

Model/Drift Velocity/Ohm

- Draw a diagram of an e^- moving in a wire.



- drift velocities are typically very low ≈ 2×10^{-4} m/s.
- The E-field inside a conductor is __0__ when charge is stationary
- Current density, $J = I/A$

e⁻e⁻e⁻e⁻e⁻e⁻ → wave moves quickly

- A current density and an E-field are established in a conductor whenever a __potential difference__ is maintained across the conductor.
- For some materials the current density is directly proportional to the E-field.

$E \propto I$

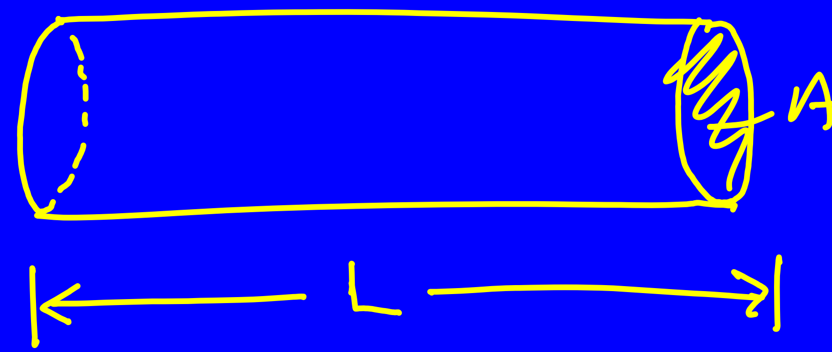
- These material obey Ohm's Law: $\Delta V = IR$

ΔV – voltage (V)
I – current (A)
R – resistance (ohms, Ω)

Ohm's Law

- σ - conductivity (how well does this material conduct)
- Resistivity, $\rho \equiv 1/\sigma$
- $\mathbf{R} = \frac{\rho L}{A}$

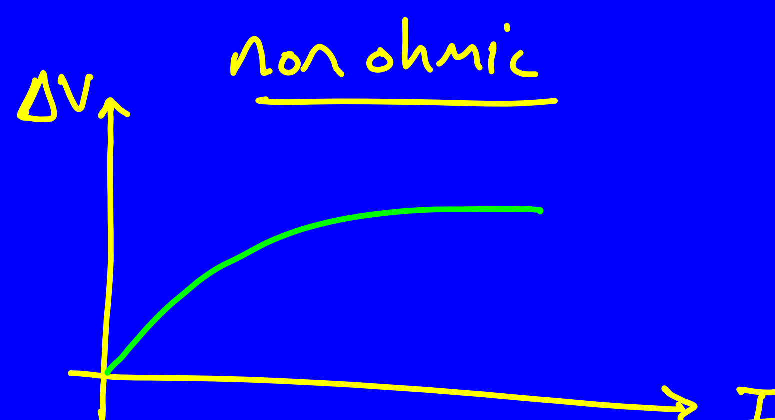
  $\rho\left(\frac{\Omega}{m}\right)$



- Table on page 847 has resistivity for materials

  ρ in book

- Graph ΔV vs. I for *ohmic* and *nonohmic* materials.



Resistance & Temperature

- Over a limited temperature range the resistivity of a metals varies with the temperature as

  $\rho = \rho_o(1+\alpha(T - T_o))$

  T_o is usually taken to be 20°C

  α is the temperature coefficient of resistivity

  $\alpha = \Delta\rho/(\rho_o\Delta T)$

  α - how does ρ change with temperature.

- Table 27.1 on page 847 has α
- Because resistance is proportional to resistivity the expression for resistance is

  $R = R_o(1+\alpha(T - T_o))$

Power

- Because charge can not build up the current is the equal ________ everywhere in the circuit.
- The rate ΔQ loses potential energy while going through the resistor is

$\Delta V = \frac{\Delta U}{\Delta Q}$

$$\frac{\Delta U}{\Delta t} = \left(\frac{\Delta Q}{\Delta t}\right) \Delta V = I \, \Delta V$$

- The power delivered to the resistor is

$P = I \Delta V = I^2 R = \frac{\Delta V^2}{R}$ (Watts = W)

- *Joule heating* is the power lost as internal energy in a conductor. (I^2R loss)

Examples

1. Consider a Nichrome wire, which has a radius of 0.321 mm. pg. 847
   a) Calculate the resistance per length of the wire. $\frac{R}{l} = \frac{\rho}{A} = 4.6\ \frac{\Omega}{m}$
   b) A 10 V potential difference is maintained across 1 m of the wire, what is the current? $\Delta V = IR$
      $10 = I\left(\frac{4.6}{1}\right) \Rightarrow I = 2.17\,A$
2. Why is a light bulb non-ohmic? temperature changes ρ
3. Why do power companies transport power at high voltages? $P = I\Delta V$, big ΔV, $I \downarrow \Rightarrow$ less loss to heating
   small ΔV, $I \uparrow$
4. The same potential difference is established across a 30 W light bulb and a 60 W light bulb.
   a) The power ratings for the bulbs assumes they are connect how? //
   b) Draw that circuit. $P = \frac{\Delta V^2}{R}$
   c) Which bulb has a higher resistance? 30W
   d) Which bulb has a greater current? 60W, $P = I\Delta V$

Ohm jokes

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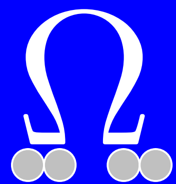
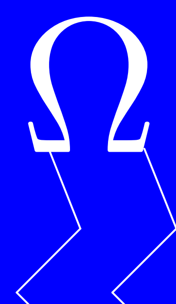
&

$$\Omega \sqrt{-1}$$

oh mi

Ohm Jokes II

1.  mobile ohm
2. ℧ (mho), Larry & Curly
3.  ohm on the range
4.  ohm run
5. Ω < ohm less