Electric current

- Charges in motion:
  - Count positive charges going from left to right
  - Add negative charges going from right to left
  - Subtract all charges moving in the opposite direction
  - Divide by time =>
- $I = \Delta q_{net} / \Delta t$
- Typically occurs inside conducting medium (wires etc.); also discharges (lightning)…
- Analog: water flowing through a pipe
- Doesn't require any NET charge, only different motion of different charges
- Unit: Ampere [A] = Coulomb/second [C/s]

Electric current II

- Electrical currents require work: *)
  - Charges keep bumping into each other and the “lattice” of positively charged atoms making up a conductor
  - This heats up the conductor (lightbulb, heater, resistor)
  - This heat energy must come from somewhere!
- Analog: water flowing through a pipe: you need a pressure difference to keep the water flowing
- => Voltage difference! (Analog to pressure difference)
- The more resistance you have in the “pipe”, the more you have to push to make a current flow: $V = RI$

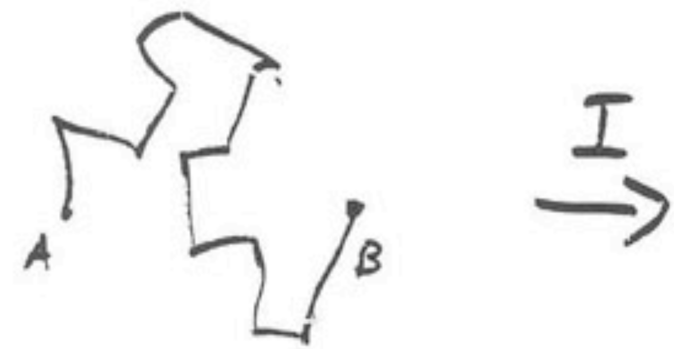
*) Except in a superconductor

Resistance

- R is the resistance of a piece of conductor
- Measured in Ω = V/A (Ohm)
- Ohm's law: $I = V/R$
- R increases with the length of the conductor and decreases with the cross section; for most metals it INCREASES with temperature
- Example: Electric shock - it's the Amperes that kill you
- Summary:
  - Because a conductor has resistance R, a voltage V is required to push a current I through
  - For the same reason, electrical energy is converted into heat
  - The higher the voltage AND the higher the current, the more energy can be converted to heat per second -> Power = $I \times V$
  - Watt [W] = Volt x Ampere [VA]
- This energy has to come from SOMEWHERE

AC/DC

- In a real conductor, there are 3 types of motions in play:
  - Extremely fast thermal motion (10^6 m/s, but random)
  - Even faster "message transmission" via **E** (all electrons move in near lockstep)
  - Net displacement of electrons over time at a snail's pace (0.05 mm/s)
  - => current



- DC current: direction of motion stays the same - electrons keep pushing through like cars on I-64 at rush hour
- AC current: direction reverses frequently (e.g. back and forth in 1/60 of a second) -> no single electron ever makes the roundtrip