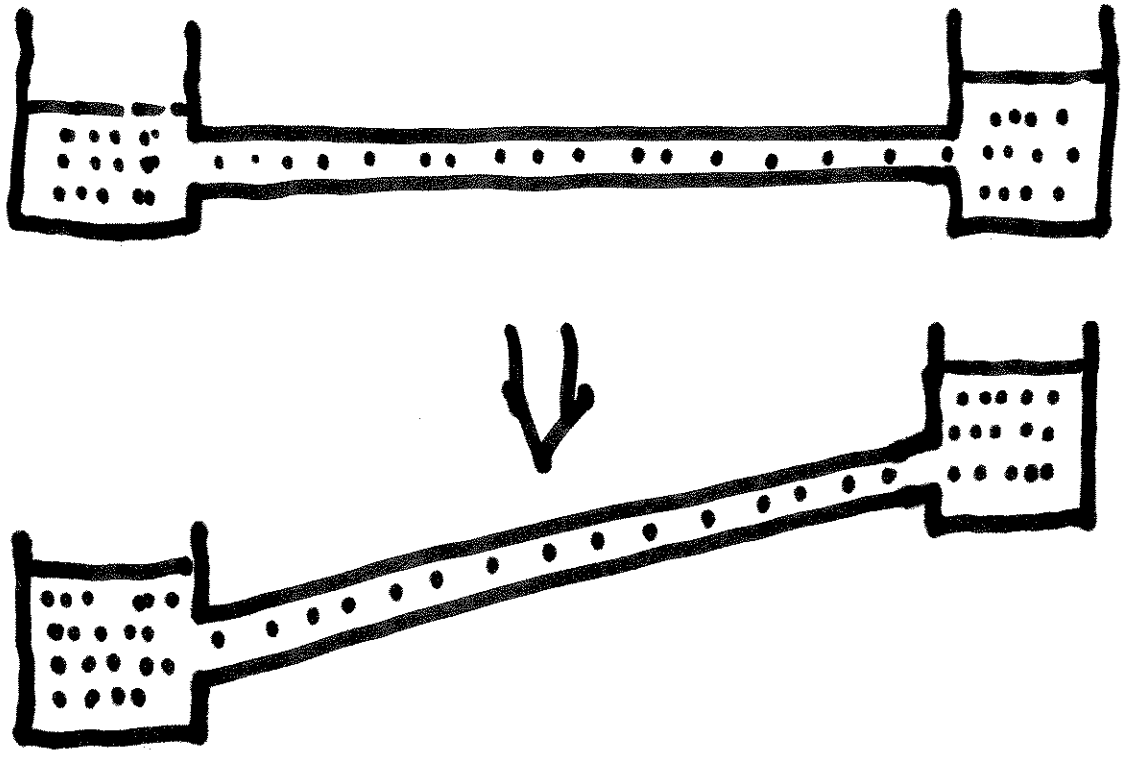
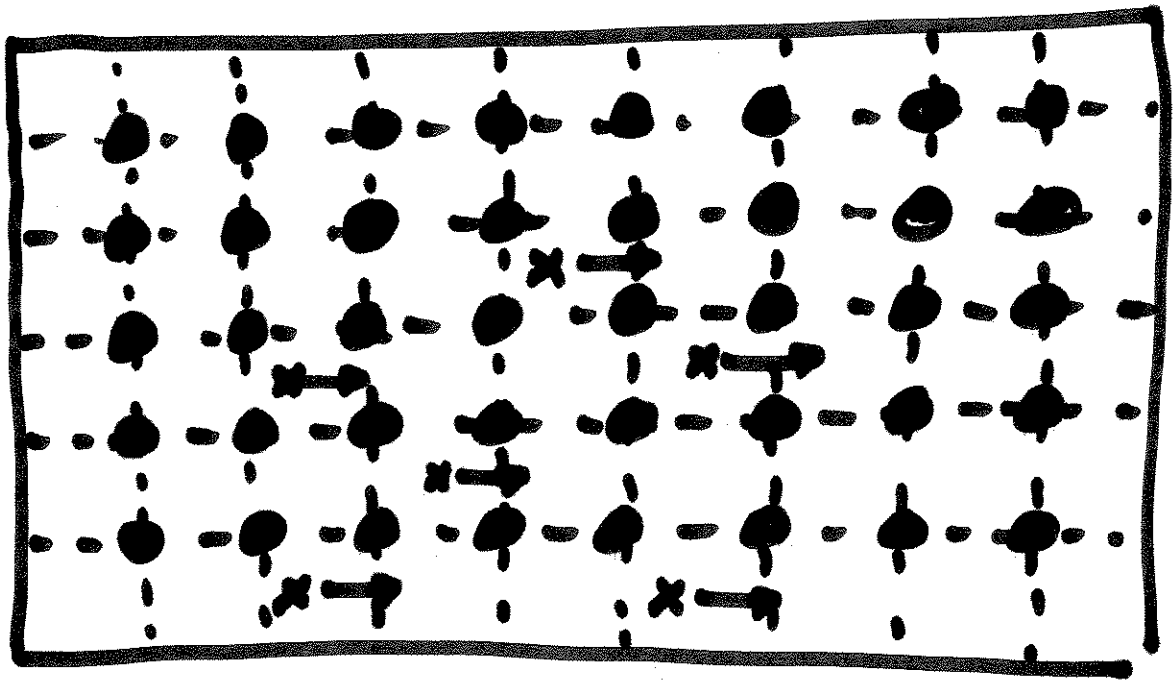
Lecture

3/1/05

ELECTRIC CURRENTS IN CONDUCTORS



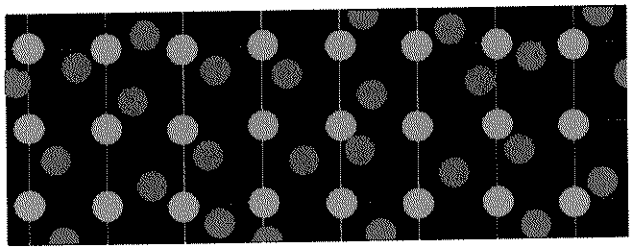
RESISTANCE



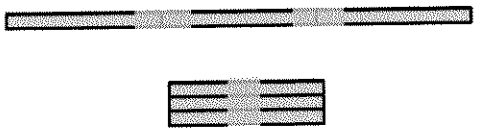
Running through a tree farm!

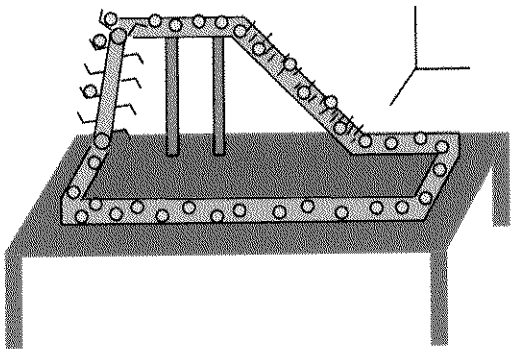
Electric Currents: Interpretation

- Our model



- Analogies
  - Air flow
  - Water flow
  - [redacted]
  - Ping-pong balls and nails

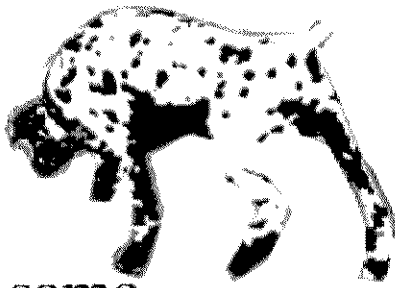




Current Footholds

- Kirchoff's laws
  - *Current conservation*: the total current entering any volume = the total current leaving that volume.
  - *Loop principle*: the sum of the voltage (pressure) drops around any loop = the sum of the rises around that loop.
  - *Ohm's law*: in any resistor, $\Delta V = IR$
- Battery rule
  - A battery is a device that maintain a constant pressure difference across its terminals.
- Wire trick
  - A wire that may be approximated as having 0 resistance is at a constant potential even when it is carrying current.

Series Rule

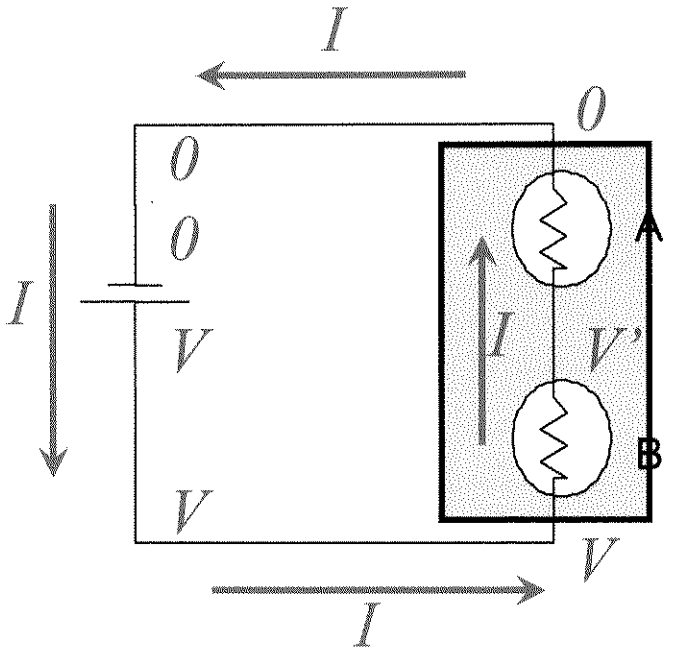


- In series, the current through each element is the same.
- In series, the pressure drop across the battery equals the sum of the pressure drops across each bulb.

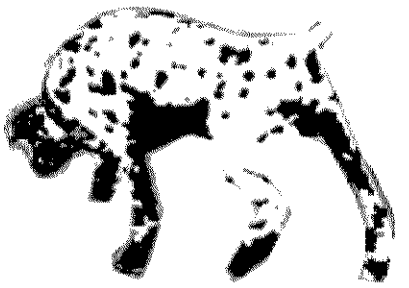
$$\underset{=V}{\Delta V} = \underset{=V'}{\Delta V_A} + \underset{=V-V'}{\Delta V_B}$$

$$IR_{eff} = IR_A + IR_B$$

$$R_{eff} = R_A + R_B$$



Parallel Rule

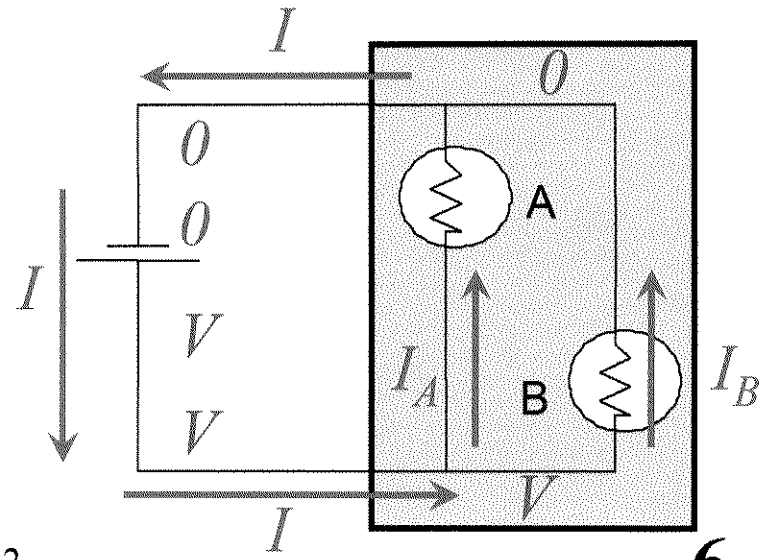


- In parallel, the pressure drop across each element is the same.
- In parallel, the current through all the elements come together and go through the battery.

$$I = I_A + I_B$$

$$\frac{\Delta V}{R_{eff}} = \frac{\Delta V}{R_A} + \frac{\Delta V}{R_B}$$

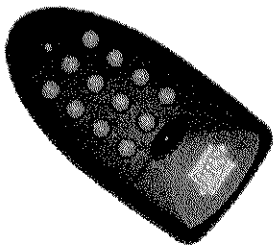
$$\frac{1}{R_{eff}} = \frac{1}{R_A} + \frac{1}{R_B}$$



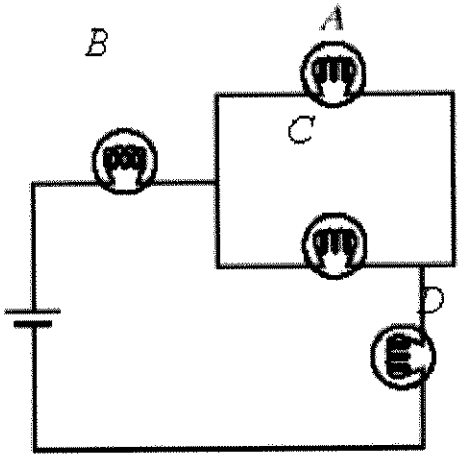
- WHY DOES A LIGHT BULB LIGHT UP?

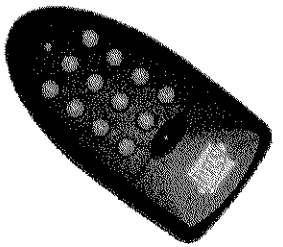
- WHAT DOES IT MEAN IF A BULB GETS BRIGHTER?

If all the bulbs are identical, then you'd expect



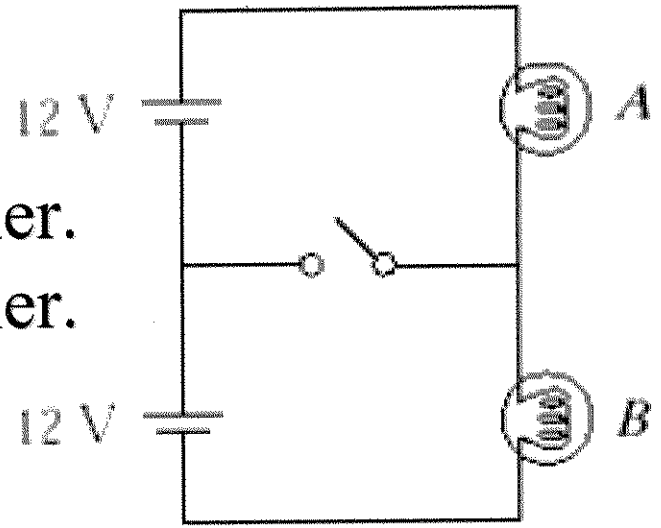
1. bulb B would be the brightest, A and C would be equal and next brightest, and D would be the dimmest.
2. bulbs A and C would be equal and brighter than B and D, which would be equal.
3. bulbs B and D would be equal and brighter than A and C, which would be equal.
4. bulb B would be the brightest, and A, C, and D would all be equally bright.
5. all bulbs would be equally bright





The light bulbs in the circuit are identical. When the switch is closed,

1. both bulbs increase in brightness.
2. A gets brighter, B dimmer.
3. B gets brighter, A dimmer.
4. both bulbs get dimmer or go out.
5. nothing changes.



Electric Power Dissipation

- We can figure out the energy needed to push the electrons through the material against the resistance using the work-energy theorem.

$$P = \frac{\Delta W}{\Delta t}$$

$$= (\text{number of charges moved}) \times$$

$$(\text{force}) \times (\text{distance moved in a time } \Delta t) / \Delta t$$

$$P = \frac{(nAL)(qE)(v\Delta t)}{\Delta t} = (nAL)qv\frac{\Delta V}{L} = (nAqv)\Delta V = I\Delta V$$