PreAP Circuits 3

Let's learn about factors that affect resistance.

Wire length: longer wires have more resistance. Why? Longer wire = more collisions for the electrons = more resistance. It is like walking thru a low tunnel where you have to walk bending over. The longer the tunnel, the harder it is to get thru.

Temperature: material tend to have higher resistance at higher temperatures. Why? Higher temperature = molecules of the conductor moving faster = more collisions for the electrons = more resistance. Like walking thru a hall of people. If they are moving it is harder to get thru. Colder = less motion = less resistance.

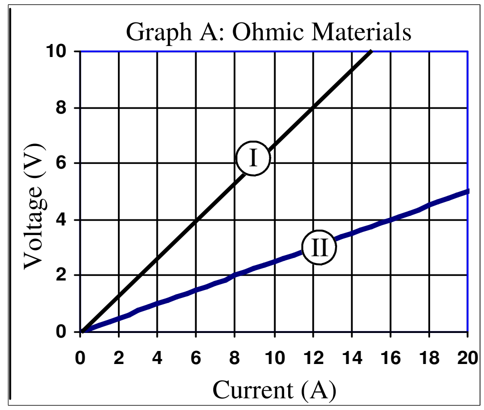
Wire thickness (or cross-sectional area): thicker wires have less resistance. Why? Wider wire = more paths for the electrons to flow = less resistance. Like walking thru a wide hall (big cross-sectional area) vs a narrow hall (small area). [A tube has a circular cross-sectional area. A box has a square cross-sectional area.]

Material: certain materials have better conductivity. Starting with the best conductor: Conductors: (Silver; Copper; Gold; Aluminum; Tungsten; Iron) Semiconductors: (Carbon; Silicon; Germanium); Insulators: (Air; Rubber; Paper; Plastics; Glass). So a good conductor is a bad insulator and vice versa.

So, resistance is directly proportional to wire length and temperature and inversely proportional to wire thickness (cross-sectional area). Here is the actual formula:

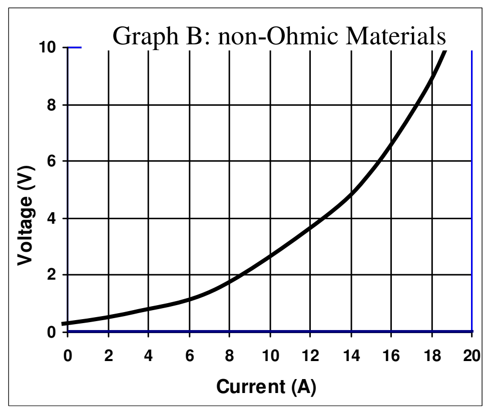
$$R = \rho \frac{\ell}{A}$$

R is resistance in ohms; ℓ is the length of the wire in m;
A is the cross-sectional area in m^2;
ρ is a conductivity constant, which depends on the material.
This equation is used only in APB, but you need to know what affects the resistance of a wire, conceptually.



Superconductors—materials that have very low or no resistance below a certain temperature. This temperature is known as the critical temperature. A superconductor is a MUCH better conductor than even silver or copper (it's SUPER!).

Ohmic vs Non-ohmic materials: Many materials follow Ohm's Law: R = V/I. As the voltage increases, the current increases at the same rate OR the resistance stays constant. A non-Ohmic materials may increase its resistance as the current increases (like many light bulbs). Graph A shows two different Ohmic materials; Graph B shows a non-Ohmic material.



1. Would the resistance increase or decrease?

   A. ____ Using a shorter wire. C. ____ Using a thicker wire.
   B. ____ Cooling the wire. D. ____ Changing from gold to silver.

2. For each of the following pairs, circle the one with the greatest resistance.

   A. A 25 Ω resistor at 5°C or at 25°C?
   B. A 5 cm long wire or a 5 meter long wire?
   C. A wire with a cross-sectional area of 3 cm^2 or 6 cm^2?
   D. Aluminum wires or Copper wires?
   E. Silver wires or wires made with a superconductor?
   F. An insulator or a conductor?

   Remember that ANY equation that has two divided variable, it means slope. Ex: V = D/T so slope of distance vs time graph = Velocity. Ex: W = Fd so F = W/d and force would be the slope of a Work vs distance graph.

3. Calculate the resistance of material I on Graph A above.

4. Calculate the resistance of material II on Graph A above.

5. Material 1 or Material 2 on Graph A above:
   A. Would be a wire at a lower temperature? B. Would be a longer wire?

6. What moves thru the crystal lattice of a metal conductor: protons or electrons?
7. * When these electrons move thru a conductor, is there a straight and unobstructed path or are there other atoms in the way?
8. * So, is the path of an electron (and therefore electricity) a straight path or a zigzag path?
   This is why it actually takes an electron about 68 minutes to move 1 meter thru a conductor.

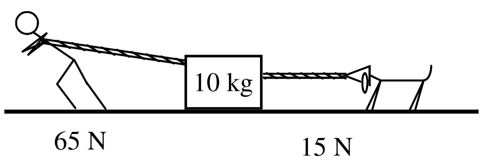
9. * When you open a water faucet in your house, do you have to wait for the water to come all the way from the pipe in the street or does it come out immediately?

10. You connect a hose to a faucet outside your house and turn on the water. Does the water come out immediately or do you have to wait for the water?

11. When you turn on a device that uses electricity (like a light bulb or radio) does it take time for the device to come on or does it come on immediately?

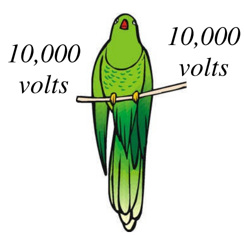
Why? Aren't there electrons already in the metal wires? When you turn on a circuit, you just push electrons into one side, which pushes all the conducting valence electrons (not the inner electrons) along the wire and the electrons at the end of the wire move out. It is virtually instantaneous.

Now, let's learn a little about voltage.



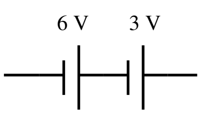
12. Slim Jim is trying to move a 10 kg box. Unfortunately his dog, Bim, is trying to be "helpful". (*Pretend Jim is pulling exactly horizontally.)*
A. How much force is actually pulling the box?
B. What is the acceleration of the box?

C. So, it is not the force that matters, but the n______ force.
This is just like voltage: only the difference of voltage matters.

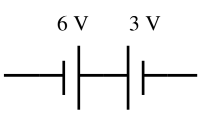


13. A bird perches on a high voltage wire.
A. What is the difference of voltage between the bird's legs?
B. How big of a shock does the bird feel?

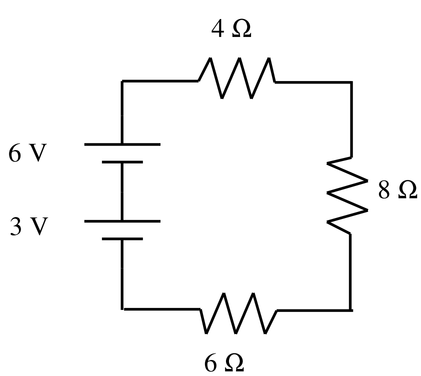
C. * What would happen if the wire sagged down until one of the bird's foot touched the ground?



14. Two batteries are placed in series as shown. What is the total voltage?



15. The second battery is then reversed. What is the total voltage?



16. Use the circuit at the left and Ohm's Law (V = IR) to answer the following.
A. What is the total resistance of the circuit?
B. What is the total voltage of the circuit?
C. * What is the total current of the circuit?

Q7) other atoms (they bump along) Q8) zigzag
Q9) immediately Q13C) mmmm….fried bird….
Q16C) 9V/18Ω = 0.5 A