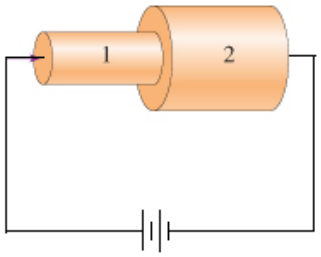
Homework 8: Serkits due 5/23

Problem 1. Two resistors are hooked up to a battery. They are made of identical material and are of identical length. Resistor 2 is obviously wider than resistor 1. So…(and provide justification).



(a) is R_1 greater than, less than, or equal to R_2?

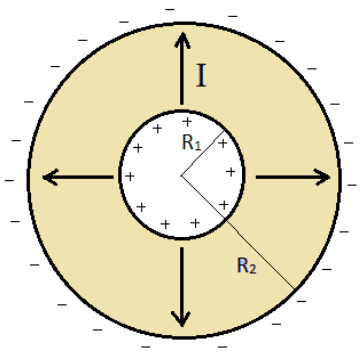
(b) is I_1 greater than, less than or equal to I_2?

(c) is ΔV_1 greater than, less than, or equal to ΔV_2?

(d) is $\mathbf{E}_1$ greater than, less than, or equal to $\mathbf{E}_2$?

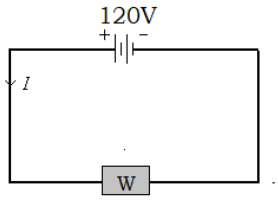
(e) is the electron drift velocity in wire 1 greater than, less than, or equal to the drift velocity in wire 2?

Problem 2. A spherical capacitor (R_1 = 3mm, R_2 = 5mm) is discharging radially outward through its dielectric. The dielectric has resistivity of 48μΩ·m. (a) If the current passing radius r = 4mm is 7.8A, what is the electric field strength at this radius? (b) And if the speed of the charges at the outer radius is v_2 = 17μm/s, what is their speed, v_1, at the inner radius? (Maaaybe want to see how I relates to electric field, and also use current conservation).



Problem 3. The electron beam inside a television picture tube is 0.50 mm in diameter and carries a current of 65 μA. This electron beam collides with the inside of the screen. If the electrons are traveling at a speed of $v = 3\times10^{7}$ m/s, what power is delivered to the screen? (Probably want to do Power = $\Delta(KE)/\Delta t$).

Problem 4. Say I have a lightbulb with a tungsten filament (diameter = 0.03mm, length = 10cm, $\rho = 5\times10^{-8}$ Ωm, density = 1900 kg/m^3, atomic mass = 183g) hooked up to a 120V battery via copper wire (diameter = 3mm, L = 20cm, $\rho = 2\times10^{-8}$ Ωm, density = 9000 kg/m^3, atomic mass = 63g).



(a) What is the current in the wire? In the tungsten filament?

(b) What is the power supplied by the battery? What is the power dissipated by the copper wire, by the tungsten filament?

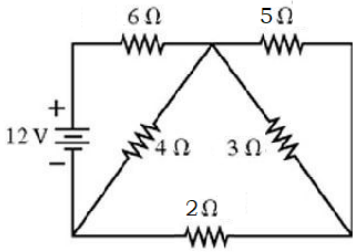
(c) What is the electric field inside the copper wire? Inside the tungsten filament?

(d) What is the electron drift velocity inside the copper wire? Tungsten filament? You can assume each contributes one electron per atom to the current.

(e) What is are the electrons' mean free collision time inside the copper wire? Tungsten filament?

(f) Fiiiinally, say the battery's lifetime is rated to be 10 Amp·hours. How much charge can it transport? How long (Δt) will it be able to light the bulb?

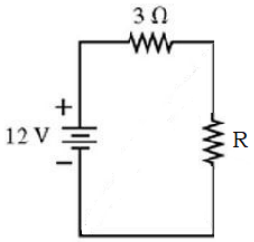
Problem 5. Say we hook up a bunch of Christmas tree lights to a 12 battery. Calculate the currents through all resistors, the power dissipated by each resistor, and then rank the resistors/lightbulbs in order of brightness. Last calculate the power supplied by the battery and the total power absorbed by the resistors.



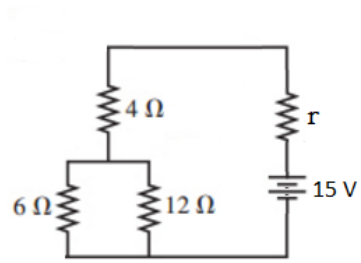
Resistor	Current	Power	Brightness
2Ω			
3Ω			
4Ω			
5Ω			
6Ω			

Power supplied	
Power absorbed	

Problem 6. Here's an interesting question. Say our 12V battery has an internal resistance of 3Ω (represented by the lovely 3Ω resistor in the diagram). And we want to illuminate our dark existence with the bightest possible light. What resistance lightbulb, R, should we plug into the circuit? Make sure you justify your answer (with calculus).



Problem 7. Over time, as the terminals on a battery corrode, they get thinner and alloyed with impurities, both of which increase their resistance (recall R = ρL/A). Say you've got a 15V car battery with internal resistance r. And, in my slightly fictional schematic adapted for the purposes of physics, a 6Ω starter motor is connected to it. If the starter motor must receive a potential difference of at least 7V to operate, what maximum value could r be?



Problem 8. Let's say the internal resistance, r, of our battery above is 1Ω, which will be insufficient to provide the requisite voltage to the 6Ω starter motor. So we 'jump' the car with another battery: 24V with 0.8Ω internal resistance. (a) What will now be the voltage across the starter motor? Will it start? (b) What will be the total power supplied to the circuit? What will be the total power absorbed?