University of Alabama
Department of Physics and Astronomy

PH 102-2 / LeClair Spring 2008

Problem Set 5: dc Circuits

Number 1. Ever seen a car with only one headlight? What does that mean about how they are wired?

Number 3. Assume they are connected in parallel. Household outlets are connected in this way so that they all receive voltage even if nothing is plugged in to some outlets. If they were in series, one empty outlet would make all the rest go dead. (That is related to question 1 as well).

Connecting in parallel also ensures they all have the same voltage, which is the basic idea behind all normal household wiring - keep the voltage fixed, and limit the current drawn with breakers or fuses. It has to be this way, since an empty wall outlet could not possibly have a certain current flowing out of it with nothing connected - one can never guarantee a specific current until something is connected, but one can guarantee a specific voltage between two unconnected wires.

Number 4. Kirchhoff's rules are necessary. Assign currents in each wire (there are three currents), and take one loop as the outer perimeter of the circuit (including the live battery and starter), and a second as the right-hand side loop (including the dead battery and the starter). Use the two equations that result from this plus conservation of current.

Number 5. Parallel resistors divide current, series resistors divide voltage.

Number 6b. First, without assuming anything at all (including what the equivalent resistance is), we can say that the total current is I, and it splits up into a current I_1 in resistor R_1, and I_2 in resistor R_2. Conservation of charge says $I = I_1 + I_2$.

Now, write down the total power. The total power is the sum of the power for each resistor. Use the fact that power is resistance times current squared:

$$\mathscr{P}_{\text{total}} = I_1^2 R_1 + I_2^2 R_2 = I_1^2 R_1^2 + \left(I - I_1\right)^2 R_2$$

This is a parabola, if you let power be the y axis, and I_1 the x axis. Find its minimum, and that gives you the current in resistor 1 which gives minimum power dissipation. It should match what you found in part a.

If you want to find the x coordinate for the minimum (or maximum) of a parabola, it has to be half way between the two possible roots. Looking at the quadratic formula, this means that the minimum or maximum *must* occur at $x = -b/2a$ - even if the roots are imaginary, the max/min will be a real number, since every parabola has to have one.

Number 10. See the online notes, chapter 6, quick questions.