PH 102-2 / LeClair   Spring 2008

Problem Set 4: Current & Resistance

Instructions:

- Answer all questions below. Show your work for full credit.
- Due before 5pm, 11 Feb 2008
- Problem sets may turned in *via* email or hard copy
- Hard copies may be left in Dr. LeClair's mailbox (Gallalee 206) or office (Bevill 228)
- You may collaborate, but everyone must turn in their own work

1. 10 points. An $11.0\,\mathrm{W}$ compact fluorescent bulb is designed to produce the same illumination as a conventional $40.0\,\mathrm{W}$ incandescent bulb. Assuming a cost of \$0.0800/kWh for electrical power, how much money does the user of the fluorescent bulb save over $100\,\mathrm{hr}$ of use?

2. 5 points. If the voltage at the terminals of an automobile battery drops from 12.3 to $9.8\,\mathrm{V}$ when a $0.5\,\Omega$ resistor is connected across the battery, what is the internal resistance?

3. 15 points. In the circuit below, if R_0 is given, what value must the R_1 have for the equivalent resistance between the two terminals a and b to be R_0?
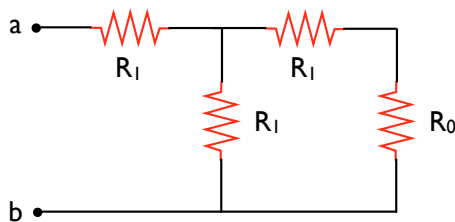
4. 10 points. An aluminum wire with a cross-sectional area of $4.00 \times 10^{-6}\,\mathrm{m}^2$ carries a current of $5.00\,\mathrm{A}$. Find the drift speed of the electrons in the wire. The density of aluminum is $2.70\,\mathrm{g/cm}^3$; assume each Al atom provides a single electron for conduction. *Hint: how many atoms per unit volume are there? How many charges per unit volume does this imply?*

5. 15 points. A regular tetrahedron is a pyramid with a triangular base. Six $14.0\,\Omega$ resistors are placed along its six edges, with junctions at its four vertices. A $9.0\,\mathrm{V}$ battery is connected to any two of the vertices. **(a)** Find the equivalent resistance of the tetrahedron between these vertices. **(b)** Find the current in the battery.

6. 5 points. A conductor of uniform radius $1.2\,\mathrm{cm}$ carries a current of $3.0\,\mathrm{A}$ produced by an electric field of $120\,\mathrm{V/m}$. What is the resistivity of the material?

7. 5 points. A common $1.5\,\mathrm{V}$ "D" cell battery can supply about $0.100\,\mathrm{A}$ of current for about $100\,\mathrm{h}$, hence its capacity rating of $10000\,\mathrm{mA{\cdot}h}$. How high could you lift yourself with one "D" cell battery powering a 50% efficient winch? Note that your mass in kg can be found by dividing your weight in pounds by 2.2.

8. 10 points. If the current carried by a conductor is doubled, what happens to the **(a)** charge carrier density? **(b)** Current density? **(c)** Electron drift velocity? **(d)** Average time between collisions?

9. 15 points. The value of an unknown resistor is to be determined with an ammeter and voltmeter, as shown below. The ammeter has an internal resistance of $0.500\,\Omega$, and the voltmeter has an internal resistance of $20,\text{k}\Omega$. Within what range of actual values of R will the measured values be correct to within 5% if the measurement is made using the circuit shown in **(a)** and **(b)**?
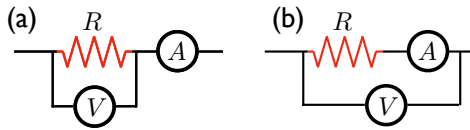
10. 10 points. All of the resistors in the figure below are equal, and have a value R. What is the equivalent resistance between the end points?