Exam 2

Phy122 Electricity and Magnetism Name:_____
July 22 2010

You have until 11:45 to complete this exam. You are allowed one index card for formulas and notes. You may have a calculator (but it probably won't help you) but no cell phones or other electronic devices are allowed. Please ask me if any questions come up during the test. I hope you do well!

1. Multiple Choice. [30 Points] Circle the correct answers.
   (a) A parallel plate capacitor has charge Q_o. The separation between the plates of the parallel-plate capacitor is then tripled, while still connected to the battery. The charge will now be:
      i. $3\ Q_o$
      ii. $1/3\ Q_o$
      iii. $9\ Q_o$
      iv. Q_o

   (b) What value might we assign to the dielectric constant for a good conductor?
      i. 0
      ii. 1
      iii. 4π
      iv. ∞

   (c) If the resistance of a heater (which plugs into a wall outlet) is doubled, its heating power will:
      i. be doubled
      ii. be halved
      iii. be quadrupled
      iv. remain unchanged

   (d) You have two identical light bulbs. You hook up one to a DC power supply, with voltage of 220V, and the other to the outlet, which has a rms voltage of 220V. What do you notice?
      i. The bulb with DC is brighter.
      ii. The bulb with AC is brighter.
      iii. They are the same brightness.
      iv. It is impossible to tell.

(e) The ideal ammeter / voltmeter would have
   i. infinite resistance / infinite resistance
   ii. infinite resistance / zero resistance
   iii. zero resistance / zero resistance
   iv. zero resistance / infinite resistance

(f) Which is more likely to kill you?
   i. 220 V and 1mΩ
   ii. 440V and 1Ω
   iii. 1000V and 1MΩ
   iv. 4000V and 1Ω

2. [10 points] Suppose you want to make a uniform cylindrical wire resistor out of $1x10^{-3}$ m^3 of iron (resistivity $\rho = 1x10^{-7}$). If the wire is to have a resistance of 10Ω, what will be the length *l* and radius *r* of this wire?

3. [20 points] Two capacitors of capacitance C1 and C2 are connected in parallel to a battery which maintains a potential difference V.
   (a) what is the equivalent capacitance C_{eq} of the combination?
   (b) What is the potential difference V_1 and V_2 across each capacitor?
   (c) what is the charge Q_1 and Q_2 on each capacitor?
   (d) repeat parts a, b, and c for the situation where the capacitors are in series.

4. [10 pts] A light bulb (with resistance R) is connected in series with an uncharged capacitor (capacitance C) and a battery (voltage V). At time t=0, a switch is closed and the circuit is complete.
   (a) Write an expression P(t) in terms of V, R,and C that describes how the power out of the bulb changes with time.
   (b) Is the light getting brighter or dimmer?

5. [30 points] Consider the circuit shown below. All of the resistors have the same resistance, R. The batteries have voltages V_1 and V_2 as shown.
   (a) This problem can be greatly simplified. Find a relation between the currents (hint: symmetry and conservation of charge might be useful) so that there are only two distinct currents. Call these currents I_a and I_b and draw the circuit again, with these currents labeled.
   (b) Use Kirchhoff's rules to set up the equations you will need to find these two unknown currents. *(note: if you didn't get part (a), just solve using all 6 branches. It will be a mess but at least I can give you points for understanding Kirchhoff's rules*)
   (c) Solve the system of equations and find the potential difference across the top resistor.

Bonus Questions: These bonus questions will add on to this test score. If you happen to get over 100, then those points can go toward your other test score.

1. [10 points] A spherical capacitor consists of a spherical conducting shell of radius *b* and charge -Q that is concentric with a smaller conducting sphere of radius *a* and charge +Q. Show that its capacitance is $C = \frac{ab}{k(b-a)}$ (where *k* is the electric constant in Coulombs law)

2. [5 points] A cube of wire has 12 resistors: one on each “edge”, as shown. All of the resistors have the same resistance ***R***. A current ***I*** flows through the cube, 'entering' at one corner and going out the far opposite corner. The current through the a given resistor can have one of two values (by symmetry). What are those two values?