Physics 5C Another Practice Midterm 1 April 2008

PRINT YOUR NAME _____

Take an hour and ten minutes to do this exam. You may use one page of formulas.

Section A (20 points): True or False. You will get 2 points for each correct answer and 2 additional points if you also give a correct brief explanation.

1. ___ Because electrons cannot travel from one plate of a capacitor to the other, no current can flow through a capacitor in a circuit.

2. ___ A dipole $\vec{p}$ points in the $\hat{y}$ direction, and is immersed in a E-field pointing in the $\hat{z}$ direction. Then positive work is done on the dipole as it turns so that it points in the $\hat{x}$ direction.

3. ___ If I take two identical capacitors and connect them in series, I will get half the capacitance of each individual one, but if I connect them in parallel, I will get double.

4. ___ The usual Gauss's law fails in a dielectric; a factor of κ must be inserted in the integral to make it valid.

5. ___ The relation $V = iR$ holds if and only if Ohm's law holds.

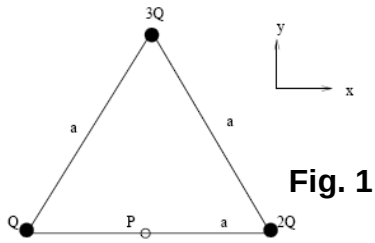

Fig. 1

Section B:

1. (14 points) Three charges, of charge Q, $2Q$, and $3Q$, form an equilateral triangle with size length a, as shown in Figure 1.

   (a) In terms of Q and a, what is the potential at point P, midway between the bottom two charges?

   (b) What are the components of $\vec{E}$ at the same point?

   (c) What is the energy of the charge configuration in Joules, if $a = 1\,m$ and $Q = 1\,C$?

2. (14 points) A metal sphere levitates inside a metal shell which in turn levitates inside another metal shell, as shown cross-section in Figure 2 (the grey parts are metal, the black parts are empty space). Initially, all three spheres are neutral. Then a charge $-Q$ is added to the inner sphere and a charge Q is added to the outer sphere, where $Q > 0$.

   (a) After the charges have reached equilibrium, will the electric field in the space between the inner and middle spheres point inward, outward, or neither?

   (b) What will be the charge on the inner surface of the middle sphere?

   (c) How much charge is on the outer surface of the middle sphere?

   (d) How much charge is on the inner surface of the outer sphere?

   (e) Make a plot of E vs. radius r, where E is the radial electric field.

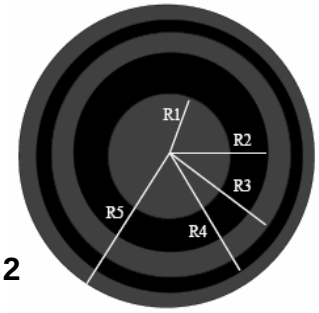

Fig. 2

3. (16 points) You are given a mysterious black box with two metal terminals sticking out. You X-ray it, and deduce that inside there is an EMF E connected in series to 2 identical resistors, each with resistance r, which are in parallel. You hook the thing up to a 21 V battery and find (using an ammeter) that there is a current of 1 A between the terminals. If you reverse the connections to the battery you find a current of 2 A in the opposite direction. Find E and r.

4. (18 points) Two conducting spheres of radius R and R are separated by a large distance. Initially, sphere 1 is neutral and sphere 2 has a charge Q. Then then the two spheres are connected by a long, thin wire.

   (a) What fraction of the initial potential energy of the configuration disappears?

   (b) Where does it go?

5. (18 points) A capacitor that allows some current to flow from one plate to the other is sometimes called a 'leaky capacitor'. We shall call it a 'resipacitor'. A parallel-plate resipacitor is made by taking a banana cream pie in an aluminum pie plate, and sticking a second pie plate on top of it. The pie plates have area A and the pie has a thickness d. Let κ and ρ be the dielectric constant and resistivity of banana cream (neglect the crust on the bottom and the meringue on the top of the pie, and assume $d^2 \ll A$).

   (a) Find RC where R is the resistance of the whole mess, and C is its capacitance.

   (b) (5 points extra credit) Consider a banana resipacitor composed of a (cylindrical) banana segment wrapped in foil, with a metal skewar through it. Show that the same expression for RC holds for it in terms of the resistivity and dielectric constant of (cream-free) banana.