Physics 5C 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. ___ Object A has a charge of +2 C, and object B has a charge of +6 C. If $\vec{F}_{\mathrm{AB}}$ is the force on object B due to object A, then $\vec{F}_{\mathrm{AB}} = -\vec{F}_{\mathrm{BA}}$.

2. ___ Tomorrow morning, you awake in the twilight zone, where the linear dimensions of every object in your bedroom have doubled but nothing outside your room has changed. If the resistivities of material are the same in the twilight zone, then your bedside lamp shines more dimly.

3. ___ The electric field does positive work on a negative charge as the charge moves from low to high potential.

4. ___ If a fully-charged parallel-plate capacitor remains connected to a battery while you slide a dielectric between the plates, then the energy stored in the capacitor decreases.

5. ___ In an RC-circuit (an EMF, a capacitor, and a resistor hooked up in series), the total work done by the EMF from when the circuit is closed until a very long time afterward is equal to the energy stored in the capacitor at that late time.

Section B (80 points total):

1. (15 points) Two resistors, R_1 and R_2, may be connected either in series or in parallel across a (resistanceless) battery of EMF $\mathcal{E}$. We would like the power dissipated by the parallel combination to be 4 times that of the series combination. If $R_1 = 100\,\Omega$, what is R_2?

2. (15 points) A point charge q is located at the center of a cube of length d.

   (a) What is the value of the electric flux $\int \vec{E} \cdot d\vec{a}$ over any *one face* of the cube?

   (b) The charge q is moved to one corner of the cube. What is now the value of the electric flux through each of the faces of the cube? (*hint:* use another symmetry argument.)

3. (14 points) Figure 1 shows a system equivalent to two parallel-plate capacitors in series, the rigid (conductive) center section of length b being movable vertically. If the plate area is A, find the equivalent capacitance of the series combination, and note that it is independent of the position of the center section.

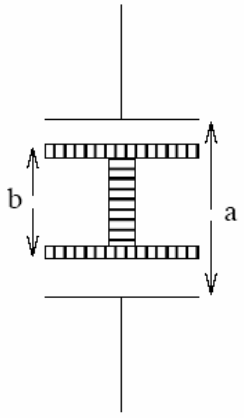

FIG. 1: For problem 3.

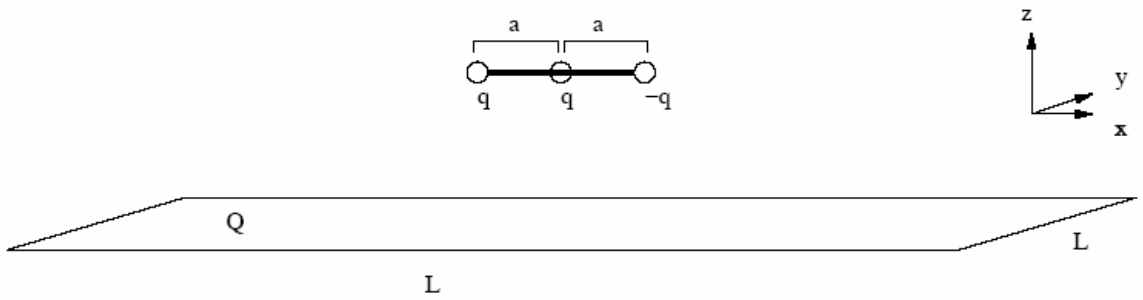

FIG. 2: For problem 4

4. (16 points) Consider the system shown in Fig. 2, consisting of a large flat non-conducting plate with charge $Q > 0$ and several charges in above it, which are attached together by an (uncharged, non-conducting) rigid bar. This bar lies along the x-axis. Assume that the distances a separating the charges, and the distance of the charges from the plate, are all very small compared to plate scale L, and let $q > 0$. (*Hint:* the best way to think about system of 3 charges is *not* as 3 individual charges.)

   (a) Calculate the (vector) net force on the system of charges.

   (b) Calculate the (vector) net torque on the system as it is shown.

   (c) *Describe qualitatively* the motion of the system if released from rest in the configuration shown. Assume there is no gravity. (A concise one- or two-sentence description will suffice.)

5. (20 points) A lightning bolt transfers $\sim 10\,\mathrm{C}$ of (negative) charge from the clouds to the Earth. The charge of the Earth is determined by an equilibrium between this charge transfer due to lightning, and the steady diffusion of electrons up through the atmosphere, which has an average conductivity of $\sigma \approx 10^{-14}(\Omega \cdot m)^{-1}$. If the Earth is taken to be a conductor, with potential $V \approx -10^9\,\mathrm{V}$ (where $V_\infty = 0$), and the radius of the Earth is $6.4 \times 10^6\,\mathrm{m}$, approximately how many lightning strikes are there per second on the Earth, on average?