UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 106-4 / LeClair   Fall 2008

Problem Set 4: Mostly Capacitance

1. **20 points.** Two long, cylindrical conductors of radius a_1 and a_2 are parallel and separated by a distance d which is large compared with either radius. Find the capacitance per unit length of the two conductors.

2. **20 points.** Find the equivalent capacitance for *both* combinations shown below. Be sure to consider the symmetry involved and the relative electric potential at different points in the circuits.

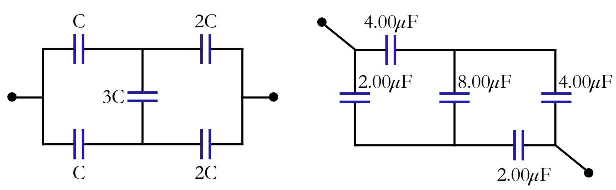

Figure 1: *Capacitor combinations.*

3. **20 points.** A capacitor is constructed from two square plates of sides l and separation d. A material of dielectric constant κ is inserted a distance x into the capacitor, as shown below. **(a)** Find the equivalent capacitance of this device as a function of x. **(b)** Calculate the energy stored in the capacitor, letting ΔV represent the potential difference. **(c)** Find the direction and magnitude of the force exerted on the dielectric, assuming a constant potential difference ΔV. Ignore friction.

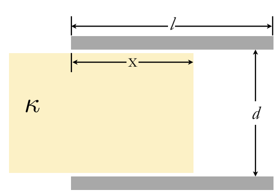

Figure 2: *Capacitor combinations.*

4. **20 points.** Using the same figure as the previous question, imagine now that the block being inserted is metal, rather than dielectric. Assume that $d \ll l$, and that the plates carries charges $+Q_o$ and $-Q_o$. **(a)** Calculate the stored energy as a function of x. **(b)** Find the direction and magnitude of the force acting on the metallic block. *Hint: a metal can be considered a perfect dielectric, $\kappa \rightarrow \infty$, which allows no electric field to penetrate it.*

5. 10 points. A charge Q is located h meters above a conducting plane. How much work is required to bring this charge out to an infinite distance above the plane? *Hint: Consider the method of images.*

6. 10 points. Two capacitors, one charged and the other uncharged, are connected in parallel. **(a)** Prove that when equilibrium is reached, each carries a fraction of the initial charge equal to the ratio of its capacitance to the sum of the two capacitances. **(b)** Show that the final energy is less than the initial energy, and derive a formula for the difference in terms of the initial charge and the two capacitances.