Physics 7B, Fall 2009, Sections 2 and 3, Instructor: Professor Adrian Lee
Second Midterm Examination, Tuesday November 3, 2009

Please do work in your bluebooks. You may use one double-sided 3.5" x 5" index card of notes. Test duration is 90 minutes.

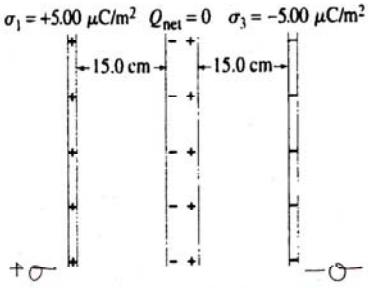
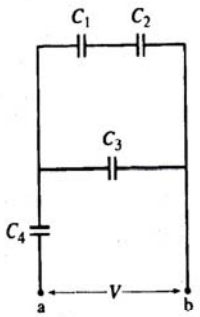


FIGURE 22–47 Problem 63.

1) Giancoli 22-63: One very large slab is in the middle of two sheets with all separations equal to d. The sheets are the end are very thin and non-conducting and have charge per unit area of $+\sigma$ and $-\sigma$ respectively. The middle slab has width and is conducting but has no net charge. For all parts, show your reasoning by simple equations or statements. Do not simply write down the answer, even if you can. [25 pts. total]
a) What is the electric field inside the middle sheet? [5 pts.]
b) What is the electric field between the left and middle sheets? [5 pts.]
c) What is the electric field between the middle and right sheets? [5 pts.]
d) What is the charge density on the surface of the middle sheet facing the left sheet? [5 pts.]
e) What is the charge density on the surface of the middle sheet facing the right sheet? [5 pts.]



2) Giancoli 24.30: Suppose in the figure that C1 = C2 = C3 = C and C4 = 2C. The charge on C2 is Q. [20 pts. total]
a) Determine the charge on each of the other capacitors and the voltage across each capacitor. Please show your detailed work. [10 pts.]
b) Determine the voltage V_{ab} across the entire combination. [10 pts.]

3) Consider a parallel plate capacitor with plate size A and gap size d. Neglect edge effects (that is, A >> d). [20 pts. total]
a) Find the capacitance by calculating E assuming a uniform charge density of both plates and calculating V from E. [10 pts.]
b) Connect a battery, and while the battery is hooked up slide a piece of dielectric with dielectric constant k into the gap. Compare C, V, Q, and the total energy before and after the dielectric is inserted. The starting values are C_0, V_0, Q_0, and $Energy_0$.[5 pts.]
c) Now, disconnect the battery and then afterwards pull out the dielectric. Compare C, V, Q, and the total energy before and after the dielectric is removed. The starting values are C_0, V_0, Q_0, and $Energy_0$. If the total energy changes where did it come from or go to?[5 pts.]

4) Consider two positive charges with charge Q, located a distance 2D apart. Take the zero point of potential to be at infinity as usual. [25 pts. total]
a) What is the potential midway between the charges? [5 pts.]
b) Along the symmetry line between the two charges, what is the potential as a function of y, the distance along the symmetry line starting from the line connecting the charges.[10 pts.]
c) Use the answer from part (b) to calculate the E field (magnitude and direction) for positions along the same line.[10 pts.]

5) A solid spherical ball that is uniformly charged with a charge density ρ and total charge Q has a radius R. Take the zero point of potential to be at infinity as usual. [25 pts. total]
a) What is the potential a distance of 2R from the ball's center? Derive the answer here from a line integral approach, do not just state a formula. [10 pts.]
b) A tiny test charge with mass m and charge q is released just at the sphere's surface at R. How fast is it going by the time it reaches 2R?[5 pts.]
c) (A more challenging problem, save for later.) What is the potential inside the ball as a function of radius r? Does it rise or fall with radius? What is the potential at the very center of the ball?[10 pts.]