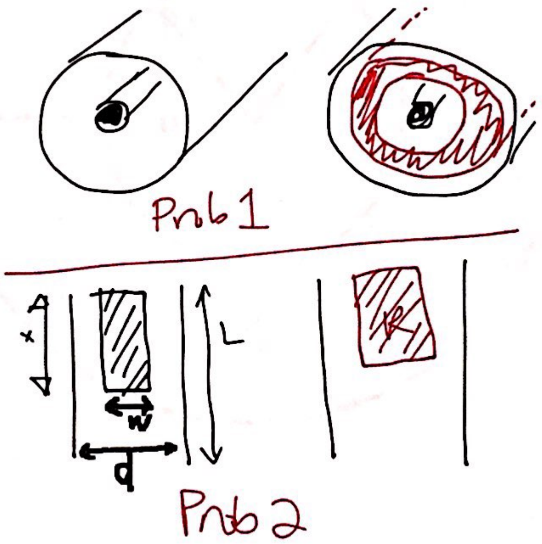
Physics 1B Discussion Problems
Week 9

[1.] Consider a coaxial cable: a long (consider it infinite) solid conducting cylinder of radius a is surrounded by a thin cylindrical metal shell of radius $d > a$ (also infinite).

(a) If I give the inner shell charge $+\lambda$ per unit length and outer shell $-\lambda$ charge per unit length, what is the electric field inside the cable? What is the potential difference between the two shells?

(b) What is the capacitance *per unit length* of the cable?

(c) Now imagine that I insert a hollow, but thick, conducting pipe between the two conductors of this capacitor. The pipe has inner radius $b > a$ and outer radius $c < d$. For the charge configuration of part [b.], what now is the potential difference between the inner and outer shells? What therefore is the capacitance per unit length of the cable? How does this capacitance compare with your answer to part [c.] (larger, smaller, or the same)?



[2.] Consider a parallel plate capacitor: two metal sheets of area A, separated by a distance d (in vacuum).

(a) I insert a slab of metal part-way into the capacitor as shown in the figure. The metal slab has width $w < d$ and has length x (the length of one side of the capacitor plate is L). What is the capacitance of this new arrangement? (Hints: you can assume that planar symmetry is not broken (e.g. use your knowledge of infinitely large parallel plates as you think about fields, etc; and you can quickly get the answer if you think about series/parallel capacitors)

(b) If I had charge Q on the plates before inserting the metal slab ($+Q$ on one, $-Q$ on the other), how does the energy stored in the capacitor change after I insert the slab? Where did energy come from/go to to change the energy stored in the capacitor)?

(c) Before I insert the slab, the charge on the plates was uniformly spread. How is the charge distributed with the slab in place? (part [d.] on back)

(d) Now instead of a slab of metal, I insert a slab of dielectric with dielectric constant κ. How does the capacitance change? What happens to the new capacitance if I let $\kappa \to \infty$ (think about this – what does $\kappa \to \infty$ mean)?

[3.] Challenge problem: Consider a spherical capacitor consisting of an inner metal spherical shell of radius r_a and an outer spherical metal of radius r_b. The capacitor is half filled with a dielectric material as shown. What is the capacitance of this arrangement? (Hint: The conductors are equipotentials. Is the electric field the same or different in the region with dielectric and in the region without?)