Phys 361 Homework 3 – Due Mon Jan 28th

1) In 3.8.1 in the book, we work through the general multipole expansion out to the quadrupole term. The general expression involving tensors is 3.91. Then the authors go and do a specific example involving two charges, work it all out and get 3.95. They then state that 3.95 agrees with 3.91 as if it is obvious. I didn't think it was very obvious. Go ahead and show that if you start from 3.91 with the pair of charges in figure 3.12 and grind it out with all the tensors and dot products, you get 3.95. The monopole and dipole terms are pretty trivial, so focus your efforts on the quadrupole term. That part is… less trivial. Note: It can be helpful to look at the monopole and dipole terms anyway to get oriented.

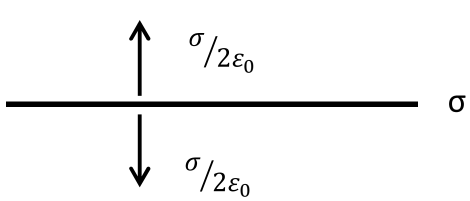
2) 3.37 in Pollack & Stump.

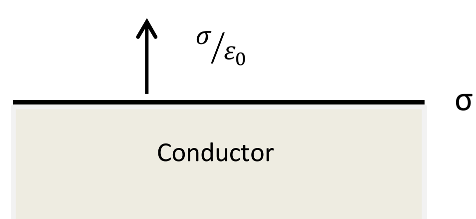
3) Problem 3.35 in Pollack & Stump.

4) Problem 3.43 in Pollack & Stump. Note: Those of you concurrently taking particle physics will probably eventually get to see a version of screening involving virtual particles. It's pretty cool. This really is a physically meaningful problem. But finding that nuclear charge density can be tricky, so if doing the math one way fails, try a different approach.

5) 4.1 in Pollack and Stump. Disregard the hint. As far as I can tell the last part of this question has a pretty straightforward answer, so don't run off trying to do tricks with line integrals (unless you want to, of course).

6) Here's something that bothered me the first time I thought of it. Consider the case of an infinite 2-D sheet of charge with uniform charge density Φ. We know that above the sheet we'll have an electric field of magnitude $\sigma/2\varepsilon_0$. Now consider another system. It's an infinite block of metal with a flat surface at z=0, as shown. At that surface there exists an identical charge density Φ. But from what we've learned, the electric field above *that* surface will be of magnitude σ/ε_0. And yes, this system is in static equilibrium





So to recap: In each physical situation we have a sheet of charge of the same magnitude. In each physical situation we have zero charge everywhere else (no free charge in the conductor). If we did direct Coulomb's law integration to find the field in either topside region, we'd <u>get the same thing in both cases</u> ($\sigma/2\varepsilon_0$; we did this on HW 1).

But somehow that's not what happens. And Coulomb's law is kind of supposed to work always. So how can this be? Don't just say "Because Gauss's Law and/or the boundary conditions demand it;" we already used Gauss's Law to find these fields. And besides, Gauss's Law and Coulomb's Law are equivalent, so having them generate different answers for the field is extra-bad. I want an explanation of how this apparent paradox can come to pass and hopefully be resolved.