PHYS 3602: Problems 1

We're just getting started, so these are easy and few.

1. Make sure you can argue why Gauss' law follows from Coulomb's law. I sketched the derivation right at the end of the last class, but will do it again with a bit more detail next class as well as giving you a few other ways to think about it. I can't overemphasize how important this is, since it's intimately tied to everything else. If you're up to it (I'll do this next week as well) show that you can get Coulomb's law from Gauss' law.

2. Find the ratio between the electrostatic attractive force between a proton and an electron and the gravitational force between them. Why do I not bother to specify a distance? If the electric force is so much larger than the gravitational one, why do we tend to only see gravitational effects at macroscopic scales and why is almost all bulk matter electrically neutral unless some effort is taken to make it charged?

(You'll have to look up the mass of a proton and of an electron in your reference of choice - I'd use wikipedia.)

3. The inverse square nature of the electrostatic force is critical for getting Gauss' law. Show that for any other power law (changing the 2 in $1/r^2$) to anything else will not work by doing the same integral (with the wrong power law) for a sphere and showing that it now depends on the radius of the sphere. As you might guess, it would also depend on the *shape* of the surface you choose so there's really nothing left of the nice result for inverse-square.

4. All of physics is connected. Assuming that charge was conserved but not locally - that is, you could teleport it from anywhere to anywhere instantly without going through space just as long as you didn't make any net charge appear or disappear. Sketch a device which would allow a light bulb to run forever, or any other perpetual motion machine of your choosing which would provide endless energy for free. Conclusion: forget about local conservation of charge and just go for it being global (that all that matters is that the total charge in the universe stays the same) and say good-bye to conservation of energy.

5. As I mentioned in class, a big problem (to my mind) of standard textbooks is an emphasis and what we know with a careful avoidance of what we don't. This makes textbooks on "established" subjects start to look like obituaries for a long-dead and fossilized field and I assure you that there is no field, however simple or long-established, that does not still have major unsolved questions. I showed you an example of static electricity (charges getting on things and staying there so that one can see the Coulomb force between them). As ancient as this subject is, dating back to amber (from whose Greek name we derive the word "electron") rubbed on fur, we still don't really have a very good understanding of who charges get separated when insulating materials touch or are pressed or rubbed together and then separated. If you're interested, have a look at EM-static-electricity-am-sci-2012.pdf which I have put in the same directory as the problems. Note that's it's from 2012 and we still haven't got it all sorted out yet! Perhaps you"ll think of another solution or a useful experiment!

P.S. If you haven't used the NU library system to access journals electronically, a good exercise is to go find this one online (you have access) and get it.