# Electrodynamics II: Assignment 1.
# Due January 18 at 11:00am in class or 10:45am in the instructor's mailbox.

1. Several short problems involving gauge transformations. We talked about a couple of these in class.
a. Show it's always possible to transform into Coulomb gauge (Jackson eqn 6.21).
b. Show it's always possible to transform into Lorentz (Lorenz) gauge (Jackson eqn 6.14).
c. Show it's always possible to transform into Weyl (or temporal) gauge $\Phi$=0. (For experts: You might ponder why this was a favorite gauge of t'Hooft.)
d. Show it's always possible to transform into axial gauge $\mathbf{n} \bullet \mathbf{A} = 0$, with constant spatial unit vector **n**. The axial gauge is often used in magnet problems where there's a symmetry axis. Prof. Ann Nelson can also explain how it's used in QFT.
e. Is there a gauge with gauge condition $\mathbf{A}$=0? Explain.
f. Demonstrate the restricted gauge transformation (Jackson eqn 6.20) preserves the Lorentz condition (Jackson eqn 6.14).

2. Consider a concentric spherical capacitor that's symmetrically and slowly self-discharging. Use the Lorentz condition, then direct integration, to find the magnetic field, if any. We briefly talked about this in class. There are integration constants to be ignored; explain why these constants can be ignored. (This is a standard problem, but I find it troublesome. The slow-discharge condition admits a quasi-static assumption, but the Lorentz condition contains a time derivative which is non-zero; hence the quasi-static assumption isn't consistently applied.)

3. Consider a localized current density $\mathbf{J}(\mathbf{r}, t) = \mathbf{J_0}(\mathbf{r})e^{-i\omega t}$ oscillating at a nearly-monochromatic frequency $\omega$. Show that the resulting magnetic field everywhere consists of a field falling as $1/r^2$ (the "induction" or "reactive" field) in the manner of Jackson eqn 5.14, plus a field falling as 1/r (a "radiation" field). Why did I add the caveat "nearly"? It happens the same is true for the electric field, but it's considerably more difficult to show.

4. Consider the retarded charge density $[\rho(\mathbf{r}', t')]_{\mathrm{ret}}$ appearing in Jackson 6.48. Does the volume integral $\iiint [\rho(\mathbf{r}', t')]_{\mathrm{ret}}\ dv'$ represent the total charge of the system? Explain. Does your reasoning apply to a system consisting of a single point charge? Explain.

[ver 10jan19 16:00]