PHYS 832 Problem Set #2 Due: February 11, 2015

1. Straightforward problem. Two point charges q are instantaneously moving in parallel lines in the x-direction, separated by distance *r*. They are moving with velocity *v* (in the x-direction).
    a. Determine the force (at that instant) they exert on each other in this reference frame *S*.
    b. Do the same by considering the reference frame S' where there is just the electrostatic force between the two charges, and transforming the force. Derive the Lorentz transformation for forces **F** for your solution.

    You will find that the force in the lab frame is smaller than in the rest frame of the moving charges, while their apparent masses are larger in the lab frame. Does this make sense? (Maybe think about time dilation and the fact that acceleration, considering **F**=m**a**, has time derivatives). Thus, the more relativistic a bunch of similar particles is (think about a bunch of protons in the LHC), the less they want to move apart from each other (kind of like focusing).

2. Moving electric dipole. Consider a dipole moment **p** that is moving in S' (in other words S' is the rest frame of an electric dipole). There is no current density in S' and otherwise no charge density other than the dipole moment. The dipole is moving with velocity $\boldsymbol{\beta}=\mathbf{v}/c$ in reference frame S. Find ρ and **J** in the S frame and show that there is a magnetic dipole moment $\mathbf{m} = (\mathbf{p} \times \boldsymbol{\beta})/2$ (correct to first order in β). What is the electric dipole moment in S (to the same order in β)?

3. Consider the same moving electric dipole **p**. In the S' frame (rest frame of the dipole), what are the scalar and vector potential fields $\Phi'(\mathbf{x}')$ and $\mathbf{A}'(\mathbf{x}')$? Transform these potentials (surely you will construct the 4-vector potential!) into the laboratory frame S, if the dipole is moving with velocity $\boldsymbol{\beta}=\mathbf{v}/c$ in reference frame S. You can show things to first order in β.