Physics 515, Spring Quarter 2018
Electrodynamics: Homework Assignment 5
Due May 9, either 11:00am in class or 10:45am in the instructor's mailbox.

1. Show that the Minkowski force density $K_\mu = \frac{1}{c}F_{\mu\nu}J^\nu$ contains the Lorentz force law. What is the physical significance of the "time" component of the force density?

2. Show that the tensor divergence of the stress tensor is the Minkowski force density: $\partial^\nu T_{\mu\nu} = K_\mu$. As we discussed in class, you can approach this by taking the divergence, exploiting the asymmetry of the field tensor, then applying the field-strength tensor Bianchi identity.

3. Consider a particle of mass *m* and charge *e* moving in the field of a fixed-position charge *q*.
a. What is the appropriate Lagrangian for this system?
b. Show that the angular momentum and total energy are constants of the motion.
c. Show that the equation of motion is
$(E - {}^{e}/_{r})^2 = \vec{p}^2 + m^2$ with $\vec{p}$ the particle momentum and *E* the total energy.
If we had carried this further, we'd find the orbits do not have a 2π periodicity, as they would non-relativistically. Another difference is that for relativistic attractive forces, the particle spirals inwards, eventually reaching the origin in a finite time, this would never happen in the non-relativistic case (except for angular momentum).` `

4. Jackson problem 13.2. In class we talked about the adiabatic approximation at the heart of the (Jackson eqn 13.6) ionization-loss equations (and variants). For this we appealed to quantum mechanics. Jackson looks at this classically in this problem. Classically, to have energy transfer, there need be a Fourier component at the natural frequency of the system.

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