# Electrodynamics III: Assignment 6.
# Due May 24 at 11:00am in class or 10:45am in the instructor's mailbox.

1. Short exercise. Show that the electromagnetic stress tensor is indeed traceless.

2. More field transformations. In the unprimed frame there are **E** and **B** fields at a certain point. Find the velocity (direction and speed) of a primed frame relative to the unprimed frame where those **E** and **B** fields are aligned in the same direction.

3. Massive photons.
a. Show that the source-free form of the Proca Lagrangian (Jackson eqn 12.91 without the interaction term) leads to the source-free Proca Equation (Jackson eqn 12.92 without the source term).
b. Show that the source-free Proca Equation leads to a Klein-Gordon equation for the massive vector field. Notice the mass appears in the usual way in this Klein-Gordon equation. This suggests incorporating mass in the form of the Lagrangian in (a) is sensible.
c. Show that the Klein-Gordon equation in (b) contains the appropriate dispersion relation for a particle with mass. Notice the mass, too, appears in the usual way in this dispersion relation. This, too, suggests the form of the Lagrangian is sensible.

4. Consider a particle of mass *m* and charge *e* moving in the field of a fixed-position charge *e*.
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 $2\pi$ 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 wouldn't happen in the non-relativistic case (except for zero angular momentum).

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