4/28/2005. **Due:** Thursday, May 5, 2005 (in class).

Physics 302/572: Electromagnetic Theory II

Read: Griffiths 12.2-12.3

"**G**, **PS**" refer to Griffiths and Pollack & Stump books respectively.
Problems with stars are not for credit and will NOT be graded.

Homework 11

Exercise 1 (G 12.26)

Find the invariant product of the 4-velocity with itself, $\eta^\mu \eta_\mu$.

Exercise 2 (G 12.29)

If a particle's kinetic energy is n times its rest energy, what is its speed?

Exercise 3 (G 12.33)

A neutral pion of (rest) mass m and (relativistic) momentum $p = \frac{3}{4}mc$ decays into two photons. One of the photons is emitted in the same direction as the original pion, and the other in the opposite direction. Find the (relativistic) energy of each photon.

Exercise 4 (G 12.35)

In a **pair annihilation** experiment, an electron (mass m) with momentum p_e hits a positron (same mass, but opposite charge) at rest. They annihilate, producing two photons. (Why couldn't they produce just *one* photon?) If one of the photons emerges at 60° to the incident electron direction, what is its energy?

Exercise 5 (G 12.36)

In classical mechanics Newton's law can be written in the more familiar form $\vec{F} = m\vec{a}$. The relativistic equation $\vec{F} = d\vec{p}/dt$, *cannot* be so simply expressed. Show, rather, that

$$\vec{F} = \frac{m}{\sqrt{1 - u^2/c^2}} \left[\vec{a} + \frac{\vec{u}(\vec{u} \cdot \vec{a})}{c^2 - u^2} \right],$$

where $\vec{a} \equiv d\vec{u}/dt$ is the **ordinary acceleration**.

*Exercise 6 (F 14.12)

A proton of mass 938 MeV has a kinetic energy 469 MeV.

a) Find its total energy E.

b) Find its momentum p.

c) Find its velocity v.

d) Find its Lorentz parameter γ.

Hint: you can leave momentum is units MeV/c.

Exercise 7 (G 12.64)

In a certain inertial frame $\mathcal{S}$, the electric field $\vec{E}$ and the magnetic field $\vec{B}$ are neither parallel nor perpendicular, at a particular space-time point. Show that in a different inertial system $\bar{\mathcal{S}}$, moving relative to $\mathcal{S}$ with velocity $\vec{v}$ given by

$$\frac{\vec{v}}{1+v^2/c^2} = \frac{\vec{E}\times\vec{B}}{B^2+E^2/c^2},$$

the fields $\bar{\vec{E}}$ and $\bar{\vec{B}}$ are *parallel* at that point. Is there a frame in which the two are *perpendicular*?