PHYS 2604
Assignment #4

Given: Tuesday, October 13, 2009
Due: Tuesday, October 20, 2009 **in class**

1. An electron is accelerated from rest through a potential difference of $2 \times 10^6\ V$. In this problem use the energy units that make most sense, multiples of eV. Calculate the momentum of the electron in two different ways, as described below.

   a) First find the electron energy. Then find the momentum directly using the energy.

   b) Now, instead, find the γ factor for the electron first. Then find $\beta = u/c$, where u is the electron's speed, and use these directly to get its momentum.

   c) What would be the energy of a photon if it were to have the momentum equal to what you calculated for the electron? Explain how you get your result.

2. A four vector $A = (A^0, A^1, A^2, A^3)$ is defined as an object that transforms under a Lorentz boost (in the x direction) as

$$A^{0\prime} = \gamma\left(A^0 - \frac{v}{c}A^1\right)$$
$$A^{1\prime} = \gamma\left(A^1 - \frac{v}{c}A^0\right)$$
$$A^{2\prime} = A^2$$
$$A^{3\prime} = A^3.$$

   Show that the scalar product of two four vectors is invariant. Namely, show that $A' \cdot B' = A \cdot B$, where $A \cdot B \equiv A^0B^0 - A^1B^1 - A^2B^2 - A^3B^3$.

3. Show that the speed of a particle whose total energy is E is

$$u = c\left[1 - \left(\frac{mc^2}{E}\right)^2\right]^{1/2}.$$

   Show that the speed of a particle whose momentum is p is

$$u = \frac{pc}{(p^2 + m^2c^2)^{1/2}}.$$

4. An object disintegrates into two fragments. One of the fragments has mass $1.00\ MeV/c^2$ and momentum $1.75\ MeV/c$ in the positive x direction. The other fragment has mass $1.50\ MeV/c^2$ and momentum $2.005\ MeV/c$ in the positive y direction. Find (a) the mass and (b) the speed of the original object.