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PHZ4390
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Homework 3

Due Monday, Sep. 16, 2013

1. (10 pts) An ultrarelativistic particle (ignore its mass) of energy E collides elastically with a nucleon of mass M at rest and scatters off with energy E' and angle θ. Find E' in terms of θ, E and M. What happens as M becomes infinite? Hint: Using conservation of 4-momentum, express the outgoing proton 4-momentum in terms of the 4-momenta of the other incoming and outgoing particles.

2. A particle of mass M at rest decays into three particles A, B, and C of different masses m_A, m_B, m_C. Unlike in the case of a two-body decay, the energies of these three particles will not be the same in all decays, i.e., they will vary from decay to decay (of course, the total energy will be equal to M and total momentum will be zero).

   Case I: The particle A has its *minimum* allowed energy.
   a. (1 pt) Draw the momentum vectors of all three particles in this case?
   b. (2 pts) What is this minimum energy for the particle A?
   c. (2 pts) What would the energies of the other two particles B and C be in this case?

   Case II: The particle A has its *maximum* allowed energy.
   a. (1 pt) Draw the momentum vectors of all three particles in this case?
   b. (2 pts) What is this maximum energy for the particle A?
   c. (2 pts) What would the energies of the other two particles B and C be in this case?

   Hint: Recall the problem of a two-body decay that we considered in the class. Once you have figured out what needs to happen for a particle A to be at its minimum/maximum energy, the rest trivially follows from the two-body decay equations.