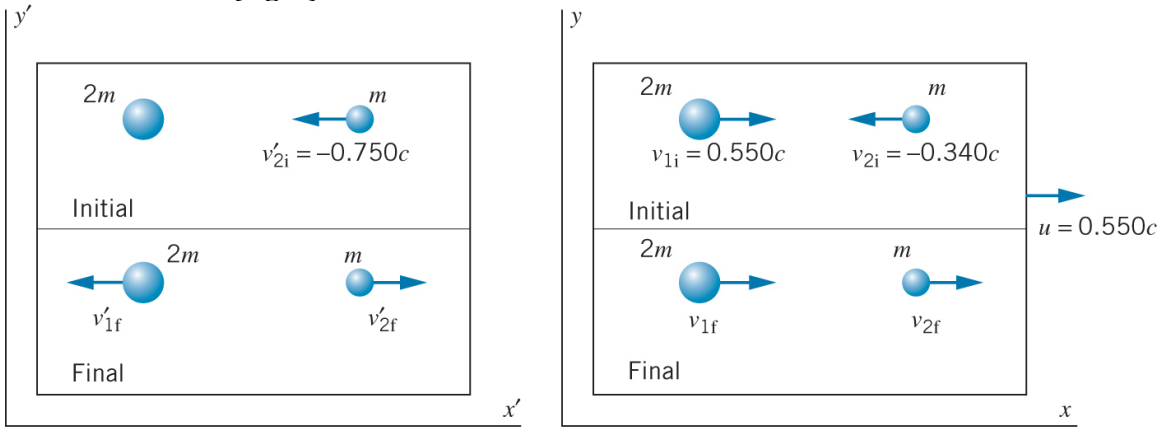
Problem Set #4

Due Friday, March 28 by 5pm to Dickinson 104

1. Taylor & Wheeler, 2nd Edition, Problem 5.6
2. Alice leaves on a rocket for Epsilon Fornacis (a star that, as opposed to Canopus, actually *is* 99 light years away). Bob, of course, stays on Earth. Before Alice leaves, she syncs her watch with Bob's. She has a ship capable of traveling 0.8c that is also capable of an instantaneous turn-around when she gets to Epsilon Fornacis (because, despite all of your advice that she can do better, she wants to get home to Bob ASAP).
    a. Draw the worldlines of both Bob and Alice on the same spacetime diagram. Make sure to put numbers on your axes and be clear about which frame the spacetime diagram is in. You might want to use graph paper.
    b. At the time that Alice reaches Epsilon Fornacis, is the separation between Alice and Bob lightlike, spacelike, or timelike? Justify your answer (i.e. with math) *in each frame.* Do your answers differ between the two frames?
3. In the figure below, a colision between two particles is shown in the O' frame (left) and the O frame (right).



    a. Using the relativistically correct final velocities for the collision shown in the left figure above ($v'_{1f} = -0.585c$, $v'_{2f} = +0.294c$), show that the relativistic kinetic energy is conserved according to observer O'.
    b. Using the relativistically correct final velocities for the collision shown in the right figure above ($v_{1f} = -0.051c$, $v_{2f} = +0.727c$), show that the relativistic kinetic energy is conserved according to observer O.
4. A neutral pion traveling along the x axis decays into two photons, one being ejected exactly forward and the other being ejected exactly backward. The first photon has three times the energy of the second. Show that the original pion had speed 0.5c.
5. At Earth's location, the intensity of sunlight is 1.5 kW/m^2. If no energy escaped from Earth, by how much would Earth's mass increase in 1 day?
6. Taylor & Wheeler, 2nd Edition, Problem 7.7
7. It is desired to create a particle with rest mass 9700 MeV/c^2 in a head-on collision between a proton and an antiproton (each having a mass of 938 MeV/c^2) traveling at the same speed.
    a. What is the speed of the created particle?
    b. What initial speed do the proton and antiproton need to have for this to occur?