PHYS-3301 Homework 5 Due 17 Oct 2012

This homework is due in the dropbox outside 2L26 by 11:59PM on the due date. If you wish to turn it in ahead of time, you may email a PDF or give a hardcopy to Dr. Frey.

1. **Twins** *From Barton 4.4 and about everywhere else*

   Frankie and Fannie are twins, born on earth at essentially the same time. At birth, Fannie is loaded onto a starship that travels to QY Aurigae, a star 20 lightyears away, at constant speed u. On arrival, the starship turns around (essentially immediately) and returns to earth at constant speed u. When the ship arrives back at earth, Fannie is 30 years old (clearly, this is a fast starship). Let's assume that Fannie isn't killed or otherwise maimed by any accelerations on the starship.

   (a) In any (correct) manner you choose, find the speed u of the starship as a fraction of light speed and Frankie's age when Fannie arrives back at earth.

   (b) What's different about Frankie and Fannie? That is, why shouldn't they be the same age?

   Note: Light speed can be written in appropriate units as $c = 1$ lightyear/year. Those units might make life easier.

2. **Pairs of Events Again** *From Barton 5.1*

   Now we revisit problem 2 from the fourth homework assignment. In this problem, you may ***not*** use the Lorentz transformations. Instead, use the fact that δs^2 is a Lorentz invariant.

   (a) In the S frame, two events happen at the same place but a time interval $\delta t = T$ apart. In S', they occur a time interval $\delta t' = 3T/2$ apart; what space interval $\delta x'$ separates the events in S'?

   (b) In S, two events happen at the same time but separated in space by a distance $\delta x = L$. In S', they occur a distance $\delta x' = 3L/2$ apart; what time interval $\delta t'$ separates the events in S'?

3. **Space Race** *Inspired by Barton 6.1*

   George Lucas has two spaceships. Without entering hyperspace, his $\times$-wing can fly at speed $c/4$, and "The Fastest Hunk of Junk in the Galaxy" (or TFHoJitG for short) can fly at $c/2$. But he wants to race them anyway, over a distance of 10 light-minutes, giving the $\times$-wing a head start. Three things happen in the race:

   A. The $\times$-wing takes off at the starting point.
   B. A while later, TFHoJitG takes off at the starting point.
   C. They arrive at the finish line at the same time.

   (a) Find the proper times between events A and B, events A and C, and events B and C.

   (b) Assume the clocks on board the ships are synchronized at the start of the race and that they accelerate essentially instantaneously. What is the difference between the clock readings on the $\times$-wing's clock and TFHoJitG's clock at the end of the race?

   (c) Draw a spacetime diagram that shows the worldlines of both ships from the reference frame of the fixed starting and ending points. Also show the worldlines of the starting and ending points. Label the worldlines clearly (you may use colors and a legend) and draw the axes perpendicular to each other.

(d) Now draw a spacetime diagram in the reference frame of the ×-wing. Again show the worldlines of the two ships, starting point, and end point, and label them clearly. Again, draw the space and time axes perpendicularly to each other.

(e) Finally, draw a spacetime diagram in the rest frame of the starting and ending poings (space and time axes perpendicular). On this diagram, draw the space and time axes associated with the rest frame of the ×-wing.

Note: A light-minute is the distance light can travel in one minute (in a vacuum).