PHYS-3301 Winter Homework 6 Due 28 Feb 2018

This homework is due in the dropbox outside 2L26 by 10:59PM on the due date. You may alternately email a PDF (typed or black-and-white scanned) or give a hardcopy to Dr. Frey.

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

   George Lucas has two spaceships. Without entering hyperspace, his ×-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 ×-wing a head start. Three things happen in the race:

   A. The ×-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 ×-wing's clock and TFHoJitG's clock at the end of the race?

   (c) Sketch 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.

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

2. **The Starship Resistant**

   Starbase SB10 emits a flash of light; according to the rest frame of SB10, starbase SB11 a distance L away along the $+x$ axis emits a flash of light a time T later. According to starship Resistant, which is travelling from SB10 to SB11, the flash from SB11 is still located a distance L away along $+x$ from the flash from SB10 but occurs a time T **earlier**.

   (a) *based on Resnick & Halliday* Find the velocity of the Resistant in SB10's rest frame.

   (b) Draw a spacetime diagram in the SB10 rest frame. Show the two flashes of light. Also draw the lightcone and the spacetime axes for the Resistant's rest frame.

   (c) Assuming that SB11 is at rest with respect to SB10, find the proper time between the flash of light leaving SB11 and arriving at the Resistant.

   (d) What proper time elapses on the Resistant between when it leaves SB10 and when it arrives at SB11? Again, assume SB11 is at rest with respect to SB10.

3. **Relativistic Monorail Revisited**

   Recall on a previous assignment that we considered a monorail between two parts of a starbase with lights spaced evenly with separation L in the rest frame of the base. The lights flash simultaneously in that frame. We also know that the lights are a distance $12L/13$ apart in the frame of the train moving along the monorail. Use the invariant interval to find the length of

time between flashes of neighboring lights in the frame of the train. Do **not** find the velocity of the train or use the Lorentz transformations.

4. **Time Since a Supernova**

   Light from supernova 1987A traveled for approximately 150,000 lightyears and arrived at earth in February 1987. Consider two events: the supernova explosion itself and a party on earth in 2017 celebrating the 30th anniversary of the discovery of the supernova. Assume there is no relative motion between the supernova and the earth between 1987 and 2017.

   (a) Are these two events spacelike, lightlike, or timelike separated?

   (b) Find the invariant interval δs^2 between the two events in square lightyears. Since we have only one significant figure, make an approximation to simplify your arithmetic.

   Supernova 1987A is one of the most important events in modern astrophysics (for reasons we will discuss more on a future assignment). An astronomer originally from Winnipeg was one of the first people to discover it!