Homework Set #2

Due Date: Wednesday July 10th

1) The Invariant
Analyze the light clock we considered in class from a third reference frame (S''), that of a rocket traveling faster than the rocket carrying the clock. Sketch a space-space diagram of the light as seen in this frame. Compute the invariant in this frame and show that it agrees with the other frames. Draw a space-time diagram in the clock frame. Label points A and B as we did in class. Add points for B as seen in the other two frames.

2) Michelson-Morley experiment
Show that the null effect of the Michelson-Morley experiment can be accounted for by Lorentz contraction.

3) Moving Balls
Imagine a spherical ball object at rest in the S' frame. Let S' be moving to the right with respect to the S frame at high speed β. According to the principle of relativity, observers in S will measure the object to be: (list all that are true)

- a) Spherical in shape, but reduced in radius by the stretch-factor γ
- b) Oblate (pancake shaped), with the short direction along x
- c) Prolate (cigar shaped), with the short direction transverse to x

4) Provisions in space
You are traveling to a star system that is 10 light years away. The star-ship on which you travel moves at 0.5c. You have trained to eat one meal a day. How many meals do you need to bring?

5) Velocity Addition
A particle moves with speed 0.9c along the x" axis of frame S" which moves with speed 0.9c in the positive x' direction relative to frame S'. Frame S' moves with speed 0.9c in the positive x direction relative to frame S. Find the speed of the particle relative to frame S.

6) Break down of Galilean Transformations
How great must the relative speed of two observers be for their time-interval measurements to differ by 1 percent ?

7) Temporal order
Show that the temporal order of two events in the laboratory frame is the same in all rocket frames if they event have time-like or like-light separation.

What goes wrong if they are space-like separated ?

8) Euclidean “slope” transformations
Show that the coordinate transformation of our Euclidean geometry analogy is given by,

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} G & -BG \\ BG & G \end{pmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix}$$

where is B is slope of the x’-axis as measured in the S frame, and $G \equiv \frac{1}{\sqrt{1+B^2}}$.