Homework 2

Due Friday, September 21st at 5pm

Finish reading Ch. 4 and read the excerpt of Ch. 5 from Hartle's book.

Read the remainder of Ch. 1, Secs. 1.1-7 in your Lyons text (pp 1-21).

Problem 1 According to clocks on the ground, two streetlights A and B situated 4 km apart were turned on precisely at 8:00 pm EST:

(a) Which one turned on first according to passengers on a high-speed train moving from A straight toward B at a speed of $3/5c$?

(b) How much later (in seconds) did the other light turn on?

(c) In the frame of the earth, are the events corresponding to the lights turning on space-like, light-like, or time-like separated?

(d) How about in the frame of the train?

Problem 2 Show that for two timelike separated events, there is some inertial frame in which $\Delta t \neq 0$ and $\Delta\vec{x} = (\Delta x, \Delta y, \Delta z) = 0$. Show that for two spacelike separated events there is an inertial frame in which $\Delta t = 0$, $\Delta\vec{x} \neq 0$.

Problem 3 A 20-m pole is carried so fast in the direction of its length that it appears to be only 10m long in the laboratory frame. The runner carries the pole through the front door of a barn 10 m long. Just at the instant the head of the pole reaches the closed rear door, the front door can be closed, enclosing the pole within the 10-m barn for an instant. The rear door opens and the runner goes through. From the runner's point of view, however, the pole is 20 m long and the barn is only 5 m! Thus the pole can never be enclosed in the barn. Explain, **quantitatively and by means of spacetime diagrams**, the apparent paradox.

Problem 4 A stick moves rightward with speed $3/5c$ with respect to the ground. The length of the stick in the ground frame is L. You move rightward with speed $1/2c$ with respect to the ground. What is the length of the stick in your frame?

Problem 5 A particle is traveling at $\frac{3}{5}c$ in the x direction. Determine its proper velocity, η^μ (all four components).

Problem 6 This week let's use Python to start to get a better handle on random uncertainties. Suppose that, like in Intro Physics, you were doing a measurement of the period of a pendulum of length ℓ made from a mass hung off a string. Newtonian theory predicts that this period will be

$$T = 2\pi\sqrt{\frac{\ell}{g}}.$$

In the laboratory, you attempt to watch exactly one period of the pendulum, that is, one back and forth trip. You use a stop watch to measure the time of flight of this trip repeatedly and get N measurements for the period. Some of these measurements are probably shorter than the true period of the pendulum because you were a bit quick in stopping the watch and others are probably a bit long. Let's assume you are careful in your measurements and they are dominated by the random chance of being a little on one side or the other of the true value. How will the distribution of your measurements look? As you take more measurements, how will your estimate of the mean of the distribution change? These are the questions that you will take up in the second Python notebook exercise.