Physics 370 Homework #2

5 problems

Due by *Wednesday*, September 7th

▷ **1.**

Let us use the Lorentz transformations to solve problem 1 from last week. To be specific: a rocket containing clock R, moving at $0.6c$, passes clock X, when clocks R and X read zero. The rocket then passes clock Y, a distance d from clock X in the ground's frame. The rocket's clock reads 8 s when it passes clock Y. We will consider three events:

A. the moment R passes X (which is also when R and X read zero)

B. the moment R passes Y

C. the moment clock Y reads zero

Here is a table showing the position and time for these three events, in the frame of the ground (unprimed) and the frame of the rocket (primed). Let's work in the units where $c = 1$ and lengths are measured in seconds.

A. R passes X	B. R passes Y	C. Y reads zero
$x_A = 0$	$x_B = d$	$x_C = d$
$t_A = 0$	$t_B =$	$t_C = 0$
$x'_A = 0$	$x'_B =$	$x'_C =$
$t'_A = 0$	$t'_B =$	$t'_C =$

(a) Find γ.
(b) What is x'_B, the position of event B in the rocket's frame?
(c) Which is true? Is $t_B = 8\,\text{s}$ or $t'_B = 8\,\text{s}$?
(d) Find d.
(e) Find the rest of the quantities in the table. (Don't turn in this sheet, recopy the table in your homework please.)
(f) Find the time on clock Y when the rocket passes it (at event B).

▷ **2.**

Suppose a person in a rocket flies by you at $v = 0.5c$. A person inside the rocket fires a gun which is able to deliver bullets that move at half the speed of light (in the gun's own frame, of course). What is the bullet's speed in your frame if
(a) it is fired in the direction of the rocket's motion
(b) it is fired in the direction opposite the rocket's motion
(c) it is fired in a direction perpendicular to the rocket's motion

▷ **3.**

Given an object moving with subluminal speed $\vec{u} = u_x\hat{x} + u_y\hat{y}$ in one frame (so that $|u| < 1$) in one frame. Find the magnitude $|\vec{u}'|$ of that speed in a frame moving with speed $v > 0$ along the $+x$–axis, and prove that $|\vec{u}'| < 1$ for all values of $u_x, u_y, v < 1$. (This is just algebra, but it requires moderately clever algebra.)

▷ **4.**

In the Earth's frame of reference, someone snaps their fingers: ten nanoseconds and 5 feet away, a firecracker goes off. (We will use the approximation $1\,\text{ft} \approx 1\,\text{light} - \text{nanosecond}$, because isn't that cool how close they are?).

(a) What is the spacetime interval Δs between these two events?

(b) To an observer moving at $0.1c$ between the fingers and the firecracker, it took 20 seconds for the firecracker to go off after the snap. How far does the firecracker appear to be from the fingers in this person's timeframe, in feet?

▷ **5.**

A spaceship orbits the Earth at a constant speed $v = 0.1c$, so that it takes $5\,\text{s}$ to go around once, according to clocks on Earth. A clock on the spaceship is visible on Earth, and during one complete orbit that clock goes from $t = 0$ to $t = T$. Find T.