Special Relativity Final Exam

Fall 2008
Instructor: Jonathan Franklin

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Name:

1 Problem One

Bob leaves the earth on a spaceship traveling at 4/5 c. Alice stays behind on earth. Their watches both read t=0 at the moment Bob's ship blasts off. When Alice's watch reads one hour, she sends a light signal toward Bob's receding ship. The light reaches his ship some time later.

(a) Draw a spacetime diagram using Alice's frame of reference. When does the light arrive at Bob's ship? What does Bob's watch read when Alice sends the light? What does Bob's watch read when the light reaches his ship?

(b) Now draw the spacetime diagram using Bob's frame of reference. What time is it (i.e., what does Bob's watch read) when Alice sends the light? What time is it (i.e., what does Bob's watch read) when the light arrives at Bob?

(c) Briefly discuss any inconsistencies, or lack thereof, between (a) and (b).

2 Problem Two

(a) Two events, P and Q, have a spacelike separation. Show in general that a rocket frame can be found in which the two events occur at the same time. Also show that in this rocket frame the distance between the two events is equal to the proper distance between them. (One method: assume that such a rocket frame exists and then use the Lorentz transformation equations to show that the relative velocity of this rocket frame is less than the speed of light, thus justifying the assumption made.

(b) Two events, P and R, have a timelike separation. Show in general that a rocket frame can be found in which the two events occur at the same place. Also show that in this rocket frame the time between the two events is equal to the proper time between them.

3 Problem Three

Briefly describe what the Michelson-Morley experiment was designed to quantify. What are implications of the result of their experiment?

4 Problem Four

A train moves to the right, relative to the tracks, at 3/5 c. A ball moves to the right, relative to the train, at 4/5 c. What is the velocity of the ball in the track frame? What is the ball's velocity in the track frame if it instead travels to the left, relative to the train, at 4/5 c?

5 The Lorentz Transformation

$$
\begin{aligned}
t &= v_{rel}\gamma x' + \gamma t' \\
x &= \gamma x' + v_{rel}\gamma t' \\
y &= y' \\
z &= z' \\
\gamma &= \frac{1}{\left(1-v_{rel}^2\right)^{1/2}}
\end{aligned}
$$