Physics 200-05
Midterm Exam
Oct 24 2005
Time: 1:00PM to 1:50PM

This exam consists of five (5) questions. All problems are worth the same number of marks.

Note: You can use

$$c = 3 \cdot 10^8 m/sec$$

1. Given that the Matricees A and B are given by

$$A = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{1}$$

$$B = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \tag{2}$$

Calculate the matrix

$$(AB - BA)^T \tag{3}$$

b) Consider the displacement 4-vector

$$\bar{p} = \begin{pmatrix} \Delta t \\ \Delta x \\ \Delta y \\ \Delta z \end{pmatrix}$$

Argue that if this represents a null (lightlike) displacement, then a Lorentz transformation takes this null displacement into another null displacement. Show that if the Lorentz transformation is in the x direction and the null displacement is in the x direction (ie, $\Delta y = \Delta z = 0$) that this null displacement vector is taken into a multiple of itself.

2) Far in the future, a runner in the 120 kilometer dash disputes his record breaking time with the official time-keeper. He says that according to his own watch, which he carried with him during the race, his time for the race was only 80% of the official time-keeper's time. What was the official time for his running of the race? (Assume that all clocks were accurate clocks and the runner is assumed to have run the race at a constant speed throughout.)(Yes, the answer is supposed to be absurd).

3) Consider two observers on the surface of the earth, at opposite sides of the earth at the equator. They both see a flash of light on the (rising/setting)

moon. What is the difference in time that they will ascribe to when the flash occured on the moon? The earth's diameter is 6000 km, it rotates once every 24 hours, and the distance from the earth to the moon is 400,000 km.

[Note that the actual **radius** of the earth is approximately 6000 km, not its diameter. If you are redoing this problem, pls use 6000 km as the radius of the earth, not its diameter. This problem should have been marked correct if you used either one. Report any marking problems to me.]

4) Peter Spacerider has heard about Relativity and heard that from the point of view of a rapidly travelling observer, his own spaceship is really short. He passes a spaceship identical to his own travelling in the opposite directioni at almost the velocity of light. Just as the nose of his spaceship is at the tail of the other spaceship he presses the button in the nose to fire the laser canon in the tail of his own spaceship at the other spaceship. His collegue Johnny says "You are an idiot. It is the other spaceship that is really short since it is travelling with respect to us. Your shot has missed." Who is right? Why? What is wrong with the other's argument. (Note, you can assume that the distance between the spaceships passing each other is much less than the length of the spaceships.)

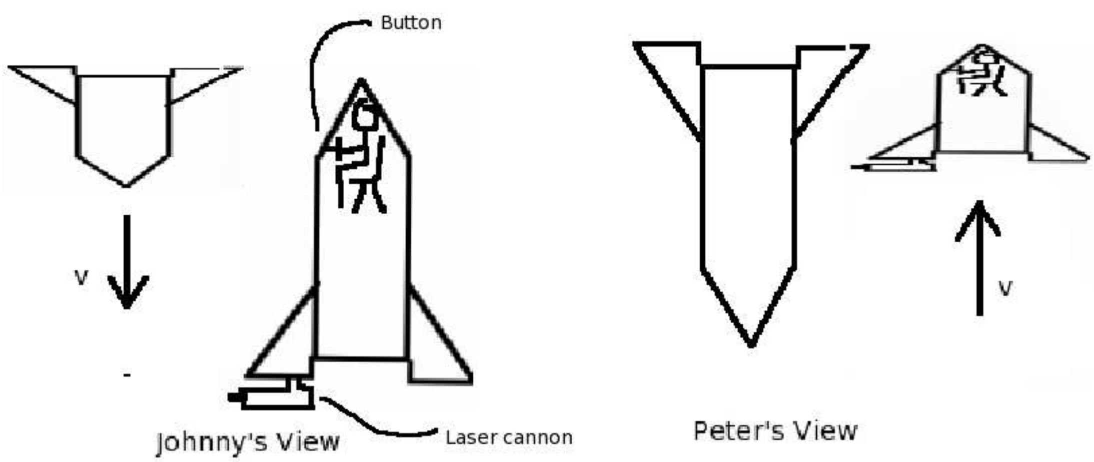

Figure 1: For Problem 4. The two views of the spaceships passing each other. Peter is in the nose of the right spaceship where he presses the button to fire the laser canon in the tail of his spaceship.

5) A Helium nucleus at rest with rest-mass energy of 4GeV absorbs a gamma ray of energy 1GeV leaving a single nucleus. What is the rest-mass of the resulting nucleus, and what is its velocity?