Physics 200-06
Midterm Exam
Oct 20 2006

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

Note that after you receive back your marked exams, you will be allowed one week to redo the exam as an assignment. The mark you get for the midterm will be the average of the two marks (the midterm proper and the midterm done as an assignment) but in any case you cannot get less than the midterm mark.

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

$$A = \begin{pmatrix} 1 & 3 & -1 \\ 0 & 1 & 0 \\ 1 & -2 & 0 \end{pmatrix} \tag{1}$$

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

which of the following exist? If they exist, what are their values?

i) AB

ii)AB^T

b)Recall that a Lorentz transformation matrix is defined by the relation

$$L^T G L = G \tag{3}$$

where G is defined by (assuming we are using units such that $c = 1$)

$$G = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{4}$$

Show that the matrix

$$L = \begin{pmatrix} \frac{5}{3} & \frac{4}{3} & 0 & 0 \\ \frac{16}{15} & \frac{4}{3} & -\frac{3}{5} & 0 \\ \frac{4}{5} & 1 & \frac{4}{5} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{5}$$

is a Lorentz transformation. Is this a boost Transformation?

2) Explain the significance of the series of experiments which led Einstein to postulate Special Relativity. What where the postulates about the world he used in deriving Special Relativity?

3) Derive the length contraction– Ie a moving meterstick appears to be shorter than the same meter stick at rest. How fast would the meter stick have

to travel so that a meter stick looked like a yard stick? (a metre is almost exactly $\frac{13}{12}$ of a yard.)

4) i) Given that the force on a particle in the rest frame of the particle is of the form

$$\bar{F} = \begin{pmatrix} 0 \\ F_x \\ 0 \\ 0 \end{pmatrix} \tag{6}$$

What is the force in a frame moving with velocity v in the +x direction? What is the magnitude of the spatial components of the force in this new frame?

ii) Joe argues that obviously things can go faster than light. Imagine applying a force to a particle to make it go at 4/5 c. Now apply that same force again to the particle and it will again increase its velocity by 4/5c bringing the total to 8/5 c which is larger than c. What (if anything) is the problem with his argument?

5) A particle with velocity $\frac{4}{5}c$ and rest mass energy of 1MeV decays into two gamma rays, with one of the gamma rays travelling in the same direction as the original particle was travelling. What is the total energy of the original particle? What is the final energy of that gamma ray which travels in the same direction as the original particle did? (Note that a gamma ray is a massless particle).