

Physics 141
Quiz 1
Tuesday, Oct. 14, 2007

Name:

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Formulae: The Lorentz Transformation

$$t' = \gamma t + \beta \gamma x \quad (1)$$

$$x' = \beta \gamma t + \gamma x \quad (2) \quad \begin{pmatrix} t' \\ x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \gamma & \beta \gamma & 0 & 0 \\ \beta \gamma & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} t \\ x \\ y \\ z \end{pmatrix} \quad (5)$$

$$y' = y \quad (3)$$

$$z' = z \quad (4)$$

Momentum 4-vector (c=1):

$$p^\mu \equiv (E, p_x, p_y, p_z) \quad (6)$$

Mass-Energy Relation (c=1) (and how to get m given E and p):

$$E^2 = p^2 + m^2; \quad E = \gamma m; \quad p = \beta \gamma m \quad (7)$$

Finding β and γ

$$\beta = p/E; \quad \gamma = E/m \quad (8)$$

Photons and other massless particles:

$$m = 0; \quad E^2 = p^2 + m^2 \Rightarrow E = p \quad (9)$$

(so a photon moving in the +x direction has 4-vector (E,E,0,0))

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Problem 1 (of 2) (Recommended time ≤ 10 minutes) Quickies (be terse):

1. State Newton's First Law

2. Define an Inertial Frame

3. State the Principle of Special Relativity (Strong Form)

4. What is the speed of light in feet per second?

5. How far does light go in a year? (use any units you want).

6. Revisit the problem on PS1- Casals is at the center of a train moving at velocity β along the positive x-axis; Primrose is on the platform. (Consider both to be at the origin of their

respective frames.) A light flashes at each end of the train and the whole thing is rigged such that the 2 flashes arrive at C and P just as C arrive right next to P. Taking the length of the train to be L in C's frame, the 2 flashes are at $(t,x) = (-L/2,-L/2)$ and $(-L/2, L/2)$, respectively, in C's frame. Draw a workable picture and transform the 2 events into P's frame.

Problem 2 (of 2) (Recommended time ≤ 10 minutes)

Consider a system of 3 identical elementary particles described at Fermilab by the 4-vectors $p_1^\mu = (E_1, p_{x1}, 0, 0)$, $p_2^\mu = (E_2, p_{x2}, 0, 0)$, $p_3^\mu = (E_3, p_{x3}, 0, 0)$.

1. Find the total energy and momentum of the system (i.e. calculate the 4-vector for the system as a whole).
2. Find the (invariant) mass of the system (you can leave it as a square if you wish).
3. Find β and γ of the system in the Fermilab frame.
4. Transform the first 4-vector into the rest frame of the system (the center-of-momentum frame).