EP 228 Particle Physics, Midterm Exam Questions

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1. (a) Write down postulates of Einstein for the Theory of Special Relativity.

(b) Show that Lorentz coordinate transformations (between two frames, *S* and *S*' where *S* is at rest and *S*' is moving in +*x* axis at a constant velocity *v* with respect to *S*, and the origins of both frames are coincide at $t = t' = 0$) are given by:

$$x' = \gamma(x - vt)\,,\ t' = \gamma(t - vx/c^2)\,,\ y' = y \text{ and } z' = z$$

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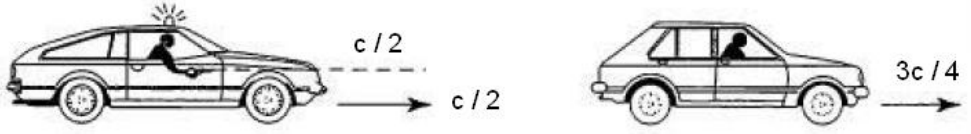
2. (a) Drive a Lorentz velocity transformation only in x-direction.

(b) An outlaws escape in their getaway car which moves at 3*c*/4. The police fires a bullet from the his car which only moves at *c*/2.The muzzle velocity (speed relative to gun) of the bullet is *c*/2. Does the bullet reach its target (i) According to pre-relativistic physics? (ii) According to relativity?



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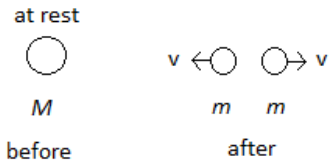
3. Consider π^0 is moving in *x*-direction and decays as $\pi^0 \rightarrow \gamma + \gamma$.
(a) What is the angle between photons if the photon energies are measured to be E_1 = 2 GeV and E_2 = 6 GeV?

(b) What is the magnitude of momentum of the mother particle (π^0)?

4. (a) A particle of mass *M*, at rest, decays into two pieces, each of mass *m*. Show that the speed of each piece is given by $v = c\sqrt{1-(2m/M)^2}$



(b) For the decay, $K_S^0 \rightarrow \pi^+ + \pi^-$, compute the speed of each decay product (pions) if the mother particle is at rest.

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5. In the following reactions, what particles are possible for the unknown particle *X*?

(a) $\pi^+ \rightarrow e^+ + X$ (weak decay)

(b) $p + p \rightarrow X + n + K^0 + \pi^+ + \pi^0$ (strong interaction)

(c) $\pi^0 \rightarrow \gamma + e^+ + X$ (electromagnetic decay)

6. The earth is constantly bombarded with high-energy particles coming from outer space. These particles are called the *primary cosmic rays* and most of them are protons. Flux of primary cosmic rays averaged over the earth surface is about $1\ \text{cm}^{-2}\ \text{s}^{-1}$ and their average kinetic energy is 3 GeV. Calculate the average power transferred (in Watts) to Earth whose radius is 6400 km.