Homework Set 2

DUE: Tuesday January 28

1(a). Write down the four vector of a massless particle with energy E. You may assume that the particle is travelling in the z direction. (1pt)

1(b). Using natural units with $c = 1$, show that a particle of energy E and momentum $\vec{p}$ has velocity $\vec{v} = \frac{\vec{p}}{E}$. (2pts)

1(c). A pion at rest decays into a muon and a neutrino. What is the speed of the muon? Pion mass $m_{\pi^\pm} = 140$ MeV and muon mass $m_\mu = 106$ MeV. (7 pts)

1(d). Cosmic ray muons are produced high in the atmosphere (at 8000 m, say) and travel toward the earth at very nearly the speed of light (say $0.998c$). If the relativistic effect is not taken into account, how for would it go? What does relativity suggest about the distance travelled by the muon? Muon lifetime is 2.2×10^{-6} s. (5pts)

2. Suppose two identical particles, each with mass m and kinetic energy T, collide head-on. What is their relative kinetic energy, T' (i.e., the kinetic energy of one in the rest system of the other)? Does this make sense in the non relativistic limit?(10 pts)

3. Perkins Problem 2.3. (10pts)

4. Perkins Problem 2.4. (10pts)

5. Perkins Problem 2.5. (10pts)

6. A satellite travels in a circular orbit about the Earth with a period of 12 h. Time between a satellite clock and an identical clock on the earth differs due to the special and the general relativistic effects.

(a). Calculate the fractional time difference between the earth and the satellite clock due to the special relativistic effect. (5 pts)

(b). Calculate the fractional time difference between the earth and the satellite clock due to the general relativistic effect. (5 pts)

(c). If these time shifts were not taken into account by the GPS, what would be the error in distance measurement after a day? (5 pts)