PHYS 3344
Fall 2019
TE Coan
Due: 9 Dec '19 6:00 pm

Homework 12

1) This problem is relevant to an experiment some of you will do in PHYS 4311 next semester. Earth's atmosphere is drizzled on by "cosmic rays" (charged particles from space). These particles decay rapidly (in their rest frame) and produce other particles called "muons' that live much longer (also when measured in their own rest frame). The half-life of these muons, when measured in their rest frame, is about $1.5\,\mu$s. Suppose a muon detector is placed on a balloon (it has been done) that rises to an altitude of 2000 m. Further suppose that in 1 hour this device detects 650 muons traveling at a speed 0.99 c toward Earth's surface. If there is an identical detect on Earth's surface, how many muons N does it detect in one hour? Do this calculation in two ways. One way is to account for relativistic time dilation and the other is to compute it classically. Clearly label the two different values for N. Recall that after n half-lives, 2^{-n} of the original population survives.

2.) Charged pions (π^+ and π^-) are sub-atomic particles that decay into muons, among other particles. They have a proper half-life (i.e., measured in their rest frame) of 1.8×10^{-8} s.

a.) What is the pion's half-life $\tau_{1/2}$ if it is measured in a frame where it is traveling with a speed of 0.8 c?

b.) Suppose now that you have 32,000 pions all created at the same place and all traveling with the same speed as in part (a). How many N_π will remain after they have traveled down an evacuated (i.e, no air that might absorb them) pipe of length $L = 36$ m. Do not forget about their half-life!

c.) Now repeat the calculation but ignore time dilation. Call this number of survivors N'. Notice the difference from the previous calculation.

3.) We have retrieved a meter stick from the demo room. It is at rest in some frame S_0, which is traveling at speed $V = 0.8$ c in our standard configuration relative to frame S.

a.) The stick lies in the x_0y_0 plane and makes an angle $\theta_0 = 60°$ with the x_0 axis (as measured in S_0). What is the length l as measured in S, and what is the angle θ with the x axis? It may be useful to think of the stick as the hypotenuse of a 30-60-90 triangle made from plywood.

b.) What is l if $\theta = 60°$ and what is θ_0 in this case?