PHYS 200: Problem Set I

Due: 4:30 pm January 25, 2005

1. [6] An athlete runs the 100-meter dash at 10 m/s. How much will her watch gain or lose, as compared to ground-based clocks, during the race?

2. [8] Two perfectly synchronized clocks A and B are at rest in S, a distance d apart. If we want to verify that they really are synchronized, we might try using a third clock, C. We could bring C close to A and check that A and C agree, then move C over to B and check the agreement of B and C. Unfortunately, this procedure is suspect since clock C will run differently while it is begin moved.

   (a) Suppose that A and C are found to be in perfect agreement and that C is then moved at constant speed v to B. Derive an expression for the disagreement τ between B and C, in terms of v and d. What is τ if $v = 300$ m/s and $d = 1000$ km?

   (b) Show that the method can nevertheless be made satisfactory to any desired accuracy by moving clock C slowly enough; that is, we can make τ as small as we please by choosing v sufficiently small.

3. [6] Muons are subatomic particles that are produced several miles above the earth's surface as a result of collisions of cosmic rays (charged particles such as protons, that enter the earth's atmosphere from space) with atoms in the atmosphere. These muons rain down more or less uniformly on the ground, although some of them decay on the way since the muon is unstable with a proper half-life of 1.5 μs (1 μs $= 10^{-6}$ s). In a certain experiment a muon detector is carried in a balloon to an altitude of 2000 m, and in the course of 1 hour it registers 650 muons traveling at $0.99c$ toward the earth. If an identical detector remains at sea level, how many muons would you expect to register in 1 hour? (Remember that after n half-lives the number of muons surviving from an initial sample of N_0 is $N_0/2^n$, and don't forget about time dilation). This was essentially the method used in the first test of time dilation, starting in the 1940's.