# 129A (Murayama), HW #1 (due Sep 12, 1997)

**1.** The *decay length* of a particle is defined as the average distance which an unstable particle can go within its lifetime $\tau$. (1) Write down a formula for the decay length as a function of $\tau$ and its velocity. (2) A $B^0$-meson (a bound state of an anti-bottom quark and a down quark) has a lifetime of $1.56 \times 10^{-12}$ s and a mass 5.28 GeV/$c^2$. If $B^0$-meson is produced with an energy of 30 GeV, what is its decay lenth? (3) Do you think we can see this distance experimentally? If yes, how?

**2.** Think of an experiment in which one sees the Lorentz contraction effect.

**3.** The SLC (Stanford Linear Collider) accelerates electron beam up to the energy of 45 GeV. (1) If the acceleration is done with an electric field of $\mathcal{E} = 10$ MV/m, how does the momentum grow as a function of time? Use the equation of motion $\frac{dp}{dt} = e\mathcal{E}$. (2) Calculate the energy and velocity as a function of time. (3) How long acceleration section do we need to achieve 45 GeV?

**4.** A TOF (time-of-flight) counter measures the arrivial time of a charged particle accurately to determine the velocity of particles. Suppose you place a TOF counter 10 m away from the point where particles ($\pi^+$-mesons and $K^+$-mesons) are created. Also suppose we know the momentum of these particles. Then the measurement of its velocity tells us its mass. By measuring the arrival time of the particles with an accuracy of 1 ns, we would like to tell $\pi^+$-mesons (of mass 140 MeV/$c^2$) from $K^+$-mesons (of mass 494 MeV/$c^2$). Up to what momentum can we distinguish them? Use the unit MeV/$c$ for the momentum.