Problem Set 1 — due April 16

1. Problem 1.3 of Griffiths.
2. Problem 3.4 of Griffiths.
3. Problem 3.16 of Griffiths.
4. Apply the result of problem 3.16 of Griffiths to the two rare B meson decay modes, $B^0 \to K^+\pi^-$ and $B^0 \to \pi^+\pi^-$, where $m_B = 5280$ MeV, $m_K = 493.7$ MeV, and $m_\pi = 139.6$ MeV. Assume the B^0 is at rest, and find the magnitudes of the outgoing momenta in the two cases. About how accurately (what percentage error) would you have to measure the momentum to distinguish the two possibilities? Now compute the velocity of the K^+ in the first case, and compare it to the velocity of the π^+ in the second case. Charged particles emit Čerenkov light when their velocity exceeds the velocity of light in a medium, c/n, where n is the index of refraction. What range of n might be used to distinguish the two decay modes, using the presence or absence of Čerenkov light as the criterion?
5. An experiment at SLAC is looking for (and just found) parity violation in electron-electron scattering, $e^-e^- \to e^-e^-$. They scatter 45 GeV electrons off electrons at rest ($m_e = 0.511$ MeV). What is the center-of-mass energy of the collision? They are most interested in scattering at 90° in the center-of-mass frame; at this angle the parity violating effects are the largest. What is this scattering angle in the lab frame, or in other words, how many milliradians from the beamline should they put their detector?

Hint: Use the fact that the transverse momenta of the final electrons are invariant under a Lorentz boost along the beamline. Also, neglect the electron mass where it is negligible.