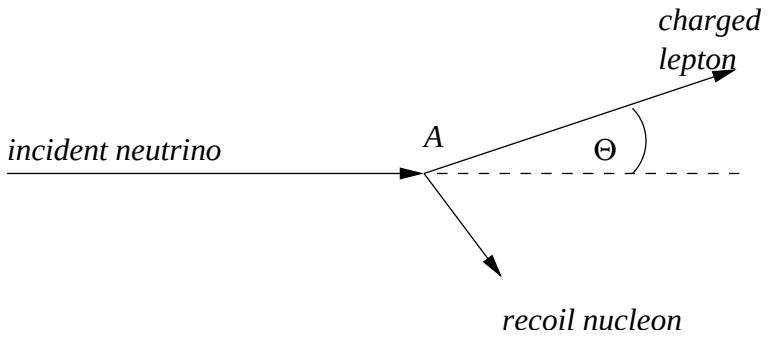
Physics 400/506
Problem Set 1
Due Tuesday January 24, 2006 by the end of class

1. In a *quasi-elastic* neutrino interaction, a ν interacts with a nucleon at rest at point A to make a charged lepton and a recoil nucleon (e.g. $\nu_\ell + n \rightarrow \ell^- + p$, with $\ell = e, \mu,$, or τ). Suppose that you detect the final charged lepton ℓ, and find that it is moving at an angle θ with respect to the neutrino's original direction of motion. Denote its energy by E_ℓ and its momentum by p_ℓ. (Of course, $E_\ell^2 = p_\ell^2 + m_\ell^2$) Solve for the initial neutrino energy E_ν in terms of E_ℓ, p_ℓ, m_ℓ, θ, and the nucleon mass m_N. (You may neglect the mass of the neutrino, and assume that $m_p = m_n \equiv m_N$.)



2. A pion in flight decays into a muon and a mu antineutrino. If the pion has a total energy of 500 MeV in the lab frame, what are the minimum and maximum possible energies of the muon after decay, in the lab frame? What is the average energy of the muon, assuming that the pion's decay products have an isotropic distribution in its center of mass frame?

3. A photon of wavelength λ collides elastically with an electron. If the photon scatters at an angle θ, what is the wavelength of the outgoing photon after it scatters?

4. The W boson has a mass of 80 GeV/c^2, and a peak width of 2.1 GeV. Suppose that the Starship Enterprise wants to shoot a beam of W's at a Romulan warbird located 10,000 km away. To what energy should the Enterprise accelerate the beam so that the average boson goes at least that far?

5. Griffiths Problem 3.16

6. Graduate students only: Griffiths Problem 3.22