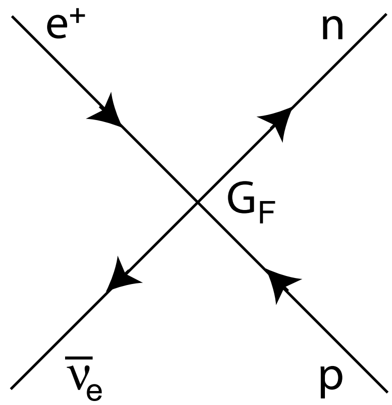
Physics 135a
Problem set number 4
Due Wednesday, February 4, 2004

Course URL: http://www.hep.caltech.edu/~fcp/ph135/

Reading: Chapter 6 of the text, on the Feynman calculus.

18. In class, we made a simple scaling argument for the energy dependence, and approximate magnitude, of an electromagnetic process. An early, and still useful, theory for the weak interaction corresponded to diagrams of the sort shown below for the amplitude for $\bar{\nu}_e p \to e^+ n$:



The coupling strength, G_F, is called the "Fermi coupling constant", and has a value:

$$G_F \approx 1.2 \times 10^{-5}\,\mathrm{GeV}^{-2}.$$

(a) By a simple scaling argument, determine the center-of-mass energy dependence of the cross section in this theory, for energies large compared with the masses involved.

(b) An experiment to measure such a cross section uses a neutrino beam incident on protons which are essentially at rest. Thus, the lab frame does not correspond to the center-of-mass frame. Determine the dependence of the cross section on the lab energy of the incident neutrino. Estimate the cross section for a neutrino energy of 50 GeV. Do not worry about possible factors of π *etc.*

Food for thought: Do you think your scaling argument gives reasonable results for very high energies? If you think it breaks down, any idea what the physics might be that does this?

19. We introduced the Mandelstam variables s, t, and u in class, and related them to different graphs for the scattering process $a+b \rightarrow c+d$. Prove the assertion we made that $s+t+u = m_a^2 + m_b^2 + m_c^2 + m_d^2$.

20. Problem 6.3 in text.

21. Problem 6.9 in text. This will give you a little practice in the δ-functionology and other arguments illustrated in chapter 6. Of course, you are encouraged to leave out those confusing $\hbar$'s and c's, setting them to 1.

22. Problem 6.11 in text.

23. Rotational Invariance and angular distribution: A spin-1 particle is polarized such that its spin direction is along the $+z$ axis. It decays, with total decay rate Γ, to $\pi^+\pi^-$. What is the angular distribution, $d\Gamma/d\Omega$, of the π^+?