Physics 880.02 Spring 1997
Due: 13 May 97

1. Compute the total width of the top quark, to lowest order in the weak coupling g. Express your answer in terms of G_F, m_t and $x \equiv (m_W/m_t)^2$ before plugging in numbers.

2. In class we wrote down the result of a similar computation, the rate for Z to decay into a fermion pair:

$$\Gamma(Z^0 \to f\bar{f}) = \frac{G_F}{6\pi\sqrt{2}} M_Z^3 (g_V^2 + g_A^2)$$

At LEP one can measure not only the width into charged leptons and quarks, but the total width as well. This allows one to count the number of light neutrinos.

(a) Compute the total width of the Z^0 at lowest order in perturbation theory (tree level). Take into account all the different charged fermion pairs available (remembering to count colors), but leave the number of neutrinos (N_ν) as a free parameter. Taking $\sin^2\theta_W = .232$, determine N_ν from the data.

(b) The answer in part (a) is not particularly close to an integer. Fix this up by putting in the most important QCD radiative corrections. These increase the hadronic width of the Z^0 by a factor of $(1 + \frac{\alpha_S}{\pi})$, where $\alpha_S(m_Z) = .120$. Revise your determination of N_ν accordingly.