215a Homework exercises 6, due Dec. 5

1. Compute $d\sigma/d\Omega$ in the center of momentum frame, to lowest nontrivial order in perturbation theory, averaged over initial spins and summed over final spins, for **nucleon-antinucleon** scattering in the theory discussed in class, taking $\mathcal{L}_I = -g\phi\bar{\psi}\Gamma\psi$, with $\Gamma = i\gamma_5$. Your final answer **must be simplified** to the point where there are no longer any things like u_p^r, nor gamma matrices. It should just involve the Mandelstam variables s and t, the masses μ (mass of ϕ) and m (mass of ψ), and g. [15 points]

2. (a) In the same theory, what is the condition needed for a ϕ quanta (meson) to be kinematically able to decay to a nucleon-antinucleon pair? (b) Assuming that this condition is satisfied, compute the meson decay rate, and total lifetime. Again, your answer should not involve any us or γ matrices. [10 points]

3. Find the units of g in the above for D spacetime dimensions (don't worry about how to define γ_5 in other spacetime dimensions - just treat γ_5 as being dimensionless in any D). Now, setting $D = 4$, explicitly verify that your answers for questions 1 and 2 above are consistent with dimensional analysis. [5 points]

4. A massive vector meson is minimally coupled to a charged Dirac particle. Compute, to lowest non-trivial order in perturbation theory, the amplitudes for fermion-fermion and fermion-antifermion scattering. You do not have to sum over spins or compute cross sections, just write down the amplitudes. Explicitly verify that the contribution of the term in the vector meson propagator proportional to $k_\mu k_\nu/\mu^2$ vanishes. [10 points]