Week 6 (due May 10)

1. Compute the 1-loop beta-function for the gauge coupling in scalar QED. (In order to make the theory renormalizable, one also needs to introduce the quartic coupling for the scalar field, which has its own beta-function, but you do not need to compute the latter. It is also easy to see that at one loop the presence of the quartic coupling does not affect the photon self-energy, so you may simply ignore the quartic coupling).

2(abc). Peskin and Schroeder, problem 12.1. Note that the presence of γ_5 in the Yukawa interaction term makes dimensional regularization suspect. At one loop, it is consistent to adopt the following procedure: do the numerator algebra (i.e. traces of gamma-matrices) in four dimensions, and apply dimensional regularization afterwards, to integrals like in eqs. (A.44)-(A.48) in the appendix in Peskin-Schroeder. Note that when computing the beta-function, it is necessary to take into account renormalization of the fields. In the pure ϕ^4 theory, this was unimportant, because there is no field renormalization at one loop level. In the Yukawa theory, one needs nontrivial Z-factors for both ϕ and ψ already at one loop, and they affect the value of the beta-functions.