Lectures and Reading Assignments:

Readings are from “An Introduction to QFT” by Peskin and Schroeder (PS); “Quantum Field Theory” by Srednicki (Sr); “Quantum Field Theory in a Nutshell” by Zee (Z).

- Lec 13, 3/18 (Tue): Vertex Function. Anomalous Magnetic Moment. **PS Sec. 6.2, 6.3; Sr Sec. 63, 64. Renormalized Perturbation Theory in QED. PS Sec. 10.2, 10.3.**
- Lec 14, 3/20 (Thu): Running Couplings and the Callan-Symanzik Equation. **Lecture Notes; Sr Sec. 27, 28; PS 12.2.**
- Lec 15, 3/25 (Tue): Running Coupling in QED. **PS Sec. 12.3; Sr Sec. 66**
- Lec 16, 3/27 (Thu): Non-Abelian Gauge Theories: Introduction **PS Sec. 15.1, 15.2; Sr Sec. 69**

Problems:

1. **Electron Scattering on Classical EM Field:** Solve PS Problems 4.4 and 5.1.

2. **Anomalous Magnetic Moment and the Higgs:** Solve PS Problem 6.3, (a) and (b). We now know that \( m_h = 126 \) GeV. Evaluate numerically corrections to the electron and muon \( g - 2 \) due to the one-loop Higgs boson diagram for this value of \( m_h \). Comment on how this compares to current experimental sensitivity of the \( g - 2 \) measurements quoted in PS. For extra credit, solve part (c).

3. **Scalar QED, Part 3:** In this problem, we will consider UV divergences and renormalization in the scalar QED theory, defined in Problems 2 and 3 on Homework 3, and further explored in Problem 1 on Homework 4.

   (a) What is the naive degree of UV divergence of an \( L \)-loop diagram with \( N_s \) external scalars and \( N_\gamma \) external photons? **Note:** Remember that there are two types of vertices in this theory, and make sure that your computation applies to both.

   (b) Make a list of all UV-divergent Green’s functions, and list the naive degree of divergence for each one. Then, list the complete set of counterterms consistent with gauge invariance. Show that there are just enough counterterms to absorb all divergences.

   (c) Compute each of the divergent Green’s functions, at the one loop order in bare perturbation theory. Use dimensional regularization, Taylor-expand in \( \epsilon = 4 - d \), and keep only terms that do not vanish in the \( \epsilon \rightarrow 0 \) limit. Your answers can contain bare Lagrangian parameters \( c_0 \) and \( m_0 \), as well as momenta entering the arguments of the Green’s functions, numerical constants, and integrals over Feynman parameters.

   (d) Now, we will formulate the renormalized perturbation theory for scalar QED. List the Feynman rules and the on-shell renormalization conditions. **[Hint: Use the usual QED as a model: see e.g. PS Fig. 10.4 and Eq. (10.40).]** Then, use your results from part (c) to compute all counterterms of scalar QED at the one-loop order.