1) **Maxwell’s equations** From Lagrangian of Eq (5.59), obtain the equations of motion for both the photon and the scalar. Verify that the electromagnetic current, defined as the right-hand side of Maxwell’s equations, is conserved.

2) **Real scalars** Consider two real scalar fields, $\phi$ and $\chi$, with an interaction Lagrangian $\mathcal{L}_I = -g\chi^2\phi$.

   a) Write out the Feynman rule for this vertex.

   b) calculate the scattering amplitude for two $\chi$ particles, $\chi\chi \rightarrow \chi\chi$. How many diagrams contribute?

3) **Complex scalars** Use the Lagrangian of Eq. (5.51) and the Feynman rule of Eq. (5.59).

   a) Compute the tree-level matrix element for the scattering of two $\phi$ particles.

   b) With a complex scalar field there are both particles and antiparticles. Compute the tree-level matrix element for the scattering of a particle and an antiparticle. (Hint: there are two diagrams).

4) **Loops** For the Lagrangian defined in Problem 2), there is no tree level matrix element for the scattering of two $\phi$ particles, but it does happen when one includes loop diagrams.

   a) Draw the Feynman diagrams for the scattering of two $\phi$ particles at one-loop order.

   b) Use the Feynman rules to write these in explicit form. However, we do not expect you to do the loop integrals. In fact, this loop integral (referred to as the box diagram) is an exceptionally complicated result.