1. What are the momentum space Feynman rules for QED?

2. In quantum electrodynamics, calculate the renormalization constant \( Z_e \) using dimensional regularization with minimal subtraction.

3. Argue that for an integral of the form
\[
\int \frac{d^n k}{(2\pi)^n} k^\alpha k^\beta k^\mu k^\nu f(k^2)
\]
you can make the replacement
\[
k^\alpha k^\beta k^\mu k^\nu \to \frac{1}{n(n+2)} [g^{\alpha\beta} g^{\mu\nu} + g^{\alpha\mu} g^{\beta\nu} + g^{\alpha\nu} g^{\beta\mu}] (k^2)^2
\]
in the integrand. Where \( g^{\mu\nu} \) are n dimensional spacetime metric, in flat spacetime it is simply \( \eta^{\mu\nu} \).

4. A bonus problem
   (You are not required to do this problem, but it’s good to do more practice and to gain extra points :) )

   Consider a theory with Lagrangian density
\[
\mathcal{L} = \mathcal{L}_0 + \mathcal{L}_{int}
\]
\[
\mathcal{L}_0 = \partial_\mu \phi^* \partial^\mu \phi - m^2 \phi^* \phi + \sum_{k=1}^2 \bar{\psi}_k (i\gamma_5 - m_k) \psi_k
\]
\[
\mathcal{L}_{int} = -g(\phi^* \psi_1 \psi_2 + h.c.) - \frac{\lambda}{4!} (\phi^* \phi)^2
\]
where \( \phi \) is a complex scalar field and \( \psi_k \)’s are Dirac fields.

   a) What are the Feynman rules?

   b) Calculate the renormalization \( Z \) factors for this theory. Use dimensional regularization with minimal subtraction. Work to order \( \lambda \) and order \( g^2 \).