QFT problem set 3

Due date: Tuesday, May 05, 2026

1. Problem 7.4 from Mandl and Shaw (page 125, 2nd Edition)

2. Problem 8.2 from Mandl and Shaw (page 158, 2nd Edition)

3. Compute the differential and total cross sections in the CoM frame for the (μ^+, μ^-) pair production process in (e^+, e^-) collisions. Present your calculations logically and in more detail than given in the book.

4. Consider the photon field A_μ in the Lorenz gauge with polarization tensor denoted by $\epsilon_{\mu r}(\vec{k})$. Explain why $\epsilon_{\mu r}(\vec{k}) \to \epsilon_{\mu r}(\vec{k}) + \lambda_r k_\mu$, corresponds to a residual gauge transformation of the photon field. Show that the complete amplitude $\mathcal{M} = \mathcal{M}_a + \mathcal{M}_b$ for the Compton scattering process $e^-(p, r) + \gamma(k, s) \to e^-(p', r') + \gamma(k', s')$ is indeed invariant under the gauge transformations $\epsilon_{\mu r}(\vec{k}) \to \epsilon_{\mu r}(\vec{k}) + \lambda_r k_\mu$ (that is, for $\mathcal{M} = \epsilon_{\mu r}(\vec{k})\mathcal{M}^\mu$, show that $k_\mu \mathcal{M}^\mu = 0$).

5. Compute the unpolarized differential cross section for Compton scattering. Present your calculation clearly, logically and in more detail than in the book.