Quantum Field Theory 1 – Problem set 12

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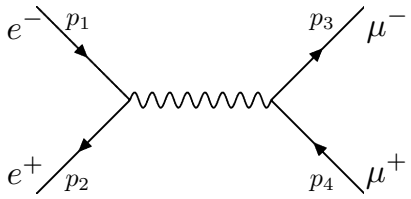
Suggested reading before solving these problems: Chapter 6.2 in the script and/or Chapter 5.1 of *Peskin & Schroeder*.

Problem 1: Tree-level cross section for $e^+e^- \to \mu^+\mu^-$

In the lecture course you have made a lot of formal developments and you are now equipped to perform calculations for real processes in QED. For example, the QED process $e^+e^- \to \mu^+\mu^-$ is an important reaction to calibrate e^+e^- colliders and therefore it constitutes a fundamental building block for the understanding and experimental study of more complicated processes in particle physics. So, ...

... take a deep breath and calculate the tree-level differential cross section[1] for the reaction $e^+e^- \to \mu^+\mu^-$ in the highly relativistic limit[2] where $s = (p_1 + p_2)^2 \gg m_\mu^2, m_e^2$.



[1] General strategy: Draw the diagram → use Feynman rules to write down $\mathcal{M}$ → square the amplitude and average or sum over spins → evaluate traces and simplify → choose a particular frame of reference → plug expression for $|\mathcal{M}|^2$ into cross-section formula and obtain differential cross section.

[2] You can follow the notes given on the lecture's website: Cross section for e+e- to mu+mu-).