Problem Set 1
PHY 782 - Fall 2018
Assigned: Monday October 1 Due: Tuesday October 16

Problem 1: Mott’s Formula

Derive Mott’s formula, which is given in Peskin, 5.1. (You do not need to derive it two
different ways as is asked in Peskin, 5.1. Just do whatever is easiest for you.)

Problem 2: Bhabha Scattering

Peskin, Problem 5.2

Problem 3: Decays of Positronium Bound States

Read pp. 148-153 and then do Peskin, 5.4, part a only

Problem 4

Consider QED with two charged spin-$\frac{1}{2}$ fields, one of which is massive, the other massless.
The Lagrangian is

$$\mathcal{L} = \bar{\psi}_1 i\not\!D \psi_1 + \bar{\psi}_2 (i\not\!D - m) \psi_2 - \frac{1}{4} F_{\mu\nu} F^{\mu\nu}.$$  

where $D_{\mu} = \partial_{\mu} + ieA_{\mu}$.

a) Write down the equations of motion for each of the fields.

b) What are the symmetries of this theory? Specify whether they are global or gauge
symmetries. Write down the conserved Noether currents corresponding to each symmetry.
Verify using the equations of motion that these currents are conserved.

c) Suppose I take the limit $m \rightarrow 0$. Are there additional symmetries? If so, write down
the corresponding Noether currents.

d) Suppose I add a term to the Lagrangian of the form

$$\mathcal{L}' = -e \bar{\psi}_2 A \psi_1 - e \bar{\psi}_1 A \psi_2.$$  

Is this interaction gauge invariant? Verify your answer by checking whether or not the matrix
element for the decay $\psi_2 \rightarrow \psi_1 \gamma$ mediated by this interaction satisfies the Ward identity.

Please write down how many hours you spent on this problem set.