Particle Physics HW8

1. Starting from the Golden Rule for the decay rate for an arbitrary decay channel (not the simplified 2-body expression), argue that it gives $\Gamma_i = 0$ if the total mass of the decay products exceeds the mass of the decaying particle. We know this is true, but I want you to tease it out of the explicit form of the Golden Rule.
2. Does the scattering cross-section enjoy the same property as the decay rate, i.e. that the total mass of what goes in must be larger than or equal to the mass of what comes out? Explain. What if initial and final total masses are the same? Do you only get one possible outcome?
3. Consider $A + A \rightarrow A + A$ in the ABC theory.
   a) Construct all of the lowest order diagrams for this process.
   b) Assuming $m_B = m_C = 0$, evaluate the total amplitude for the process to lowest order. Each contribution can be written in terms of an unevaluated integral over the internal momentum q.
   c) Use your result and the Golden Rule to calculate $\frac{d\sigma}{d\Omega}$ for this process to leading order. Remember, this is a true 2-body scattering event.
4. Construct all of the diagrams that contribute to the decay of A in the ABC theory to the next order beyond what we did in class. No need to evaluate the diagrams, just draw them. You will quickly see why higher order sucks.
5. Verify the orthonormaility condition for spinors stated in lecture for one example of each case, i.e. $s = s'$ and $s \neq s'$. Note: The explicit expressions for the spinors are given in the notes. You should make sure to use the expressions for the spinors and γ^0 from the new convention (given in the lecture).
6. Verify the completeness relationship for at least one case of spinors. Make sure all of your expressions are using the new conventions. This can be pretty tedious if you allow all three components of the momentum to be nonzero. You can get the gist of how it works if you just work it out for a single nonzero component.
7. Verify that the propagator for a spinor is indeed i times the inverse of the Dirac operator, $\gamma^\mu P_\mu - mc$, as discussed in class. Hint: It will help to revisit HW 4 problem #5 for some useful results. That case was done in position space, but you can easily translate the result to momentum space.