MARKUS KLUTE: Welcome back to 8.701. So in this lecture, we are going to start looking at an example of the QED process, for which we can now, with all the tools we have in hand, calculate the matrix elements' transition amplitude.

All right. In more general terms, we can look at all the examples. And they are listed here-- second-order processes and one third-order process. We are going to discuss them in more detail as we go along. This is really just to give you some feedback for the different kinds of processes we're going to look at.

So the first one is elastic scattering. And muon-electron scattering, that's the one process we're going to look in more detail. Why? Because this is the simplest case. For this process, there is only one leading-order diagram, which is exactly the one shown here.

For other processes where have the same particle interacting, we find that we do have to consider multiple diagrams-- for example, this one here, where we have electron and electron scattering. And so we have to calculate not just this leading diagram, which looks exactly like the one for the muon scattering, but we also have to include the [INAUDIBLE] where we change the outgoing electron leg. And so on.

And other processes are including electron-positron scattering, which is caused Bhabha scattering, Compton scattering, which we discussed the kinematics for already, but also inelastic processes like pair annihilation or pair production.

There's a very interesting diagram here, which is the third-order diagram, which is responsible for the anomalous magnetic moment. And we'll talk more about that when we talk about higher-order interactions.

So let's have a look at this electron-muon scattering process. So only one diagram contributes at the second order. And so you have an electron and a muon scattering via the exchange of a photon. This is after all of QED diagram.

So now, how do we calculate the matrix element? We simply just follow the Feynman rules-- Feynman rules as we discussed them before. And if you want to do this now, you draw your Feynman diagram. It's always very good and useful to draw a Feynman diagram first and label accordingly. That's super-useful if you want to systematically evaluate this process.

And then you start going backwards from an outgoing leg back to the initial leg. And you see this part here. You have the u3, the third particle here, the vertex vector, and the first particle. Then you have a propagator here for your photon. It's given by minus i g mu,nu divided by q square.

And then you analyze the second part here. Here you find the first particle, vertex vector, and the second particle. For each of those lines, you have to make sure that energy and momentum is converted into those [INAUDIBLE] delta functions. And then the last part you have to do, integrate over your momentum.

All right. That's already the end. The next step in your list of rules is carry out the integration. Integrate over q. That drops your delta function, but you are left with one delta function which you are also supposed to drop, which then gives you your matrix element.

Now, here we're already done. If you now further want to evaluate this diagram, you actually have to be more explicit about the spinors involved. What needs to be done now is have a discussion on how to handle the spin of the particles, meaning being explicit about the spinors. And in order to do that, we'll discuss how we treat spin, how we have to treat spin, either in an experiment where the spin of the initial particle is known or an experiment where we have to average over all possible spin states. So that's part of the next lecture discussion.