PROFESSOR: So that's part of this story. Let's try to understand it a little better still. So what does the state look like? Well the state looks like e to the ikxx times a state of the oscillator and y.

OK. So what is happening here? We could re-solve this problem using a different gauge. And you will. You will solve it at least once or twice. Again, this problem using a different gauge.

And the solutions are going to be looking a little different but, of course, you're going to find the same Landau levels and the same infinite degeneracy. The wave functions will look sometimes a little more intuitive. So in this case, one calculation that is interesting to try to understand the physics of this degeneracy is to work roughly a little heuristically on a finite size sample. Imagine a material but it's now finite size.

So let me remark to you what are the degrees of freedom you have here. Suppose you solve this Schrodinger equation in a different gauge, a symmetric gauge in which there is an ay and an ax. Solutions then are going to look a little more like circular orbits. There's a little more mathematics involved in solving it but they're going to look a little nicer.

But how are they related to this one? Well anyone with a circular orbit must be related to this solution by first forming a superposition of those solutions, maybe localizing it or doing something and then doing a gauge transformation. So in order to compare your solutions in different gauges, you have to dig into gun, you have an infinite degeneracy, and you have gauge transformation. So to see what state here corresponds to a particular state here, it may be the gauge transformation of a particular superposition in this side. So it's, in general, not all that easy to do.

OK. So let's take a count state in a finite sample. So same picture, but now the material is here. And we'll put Lx and Ly here. So finite size in the Lx, finite size in Ly. So given our intuition with quantization, this suggests that we impose periodic boundary conditions in x and try to quantize the kx here.

In general, if you're imposing thinking of very large boxes, which is the case here, it doesn't matter much whether you impose periodic or vanishing boundary conditions or anything essentially at large number of states it makes no difference. So we quantize in x. So we want e to the ikx times x to be periodic under x goes to x plus Lx. I'm almost done with sine. So kxLx will have to be equal to a multiple with Nx.

Since we know that Y0 is equal to minus kxlb squared, we should take Nx negative so that you're within the sample. You must be in y positive and therefore kx should be negative, Nx should be negative. And now I have a way to count because I can take Nx negative up to some value minus Nx bar. And when Nx grows, kx grows and y grows. So I can take the last Nx that I can use is the one in which the orbit is still in the sample up to the value Y0.

So this number is really the degeneracy because this is how many values of Nx I can have, from minus Nx up to 0, are the number of values that are consistent with a state still in this sample. So Y0 equal to Ly should be equal to minus kx times lb squared. So it's minus 2 pi Nx bar over Lx times lb squared. And this gives you Nx. We can solve for Nx there.

Nx is LyLx over lb squared over 1 over 2 pi. So Nx is the degeneracy. This is the degeneracy. And it's equal to the area divided by lb squared, which is h bar c over qB times 1 over 2 pi. So it's equal to area times b divided by 2 pi h bar c over q.

So we're back to the kind of thing we were saying before in which the degeneracy is equal to the flux divided by the flux quantum that we figured out earlier today. So this is how much states you can put on the sample. So you're given a magnetic field, a Tesla and you have some area. You find the fi, you divide by fi0, and that's the number of degenerate states of each Landau level.

So in particular, given that we have that number that fi0 is equal to about 2 times 10 to the minus 7 Gauss then centimeters squared. If you have a sample of 1 centimeter squared and you put one Gauss, the value of the flux over fi0 would be 1 Gauss centimeter squared over 2 times 10 to the minus 7 same units. So it's about 5 million states. That's just to give you an idea of how big the numbers are. That's the degeneracy.

So this is a classic problem. Very important in condensed matter physics. Is a first step in trying to understand quantum Hall effect on many things. And it's important to solve it and think it in several ways. And I think you will be doing that in homework and recitation.