MARKUS KLUTE: Welcome back to 8.20, Special Relativity. In this section and also the next one, we're going to make a case against aether. Aether was presumed to be the medium in which light traveled. We do this-- we make this case by studying the Michelson-Morley experiment. Michelson and Morley went out to detect the motion of the Earth relative to aether. And by not finding the result, we can conclude that, at least in this form, aether doesn't exist.

So what is the experimental setup? Also, it's shown in the pictures above. We have a light source here, through which the light travel to some mirror which reflects about half the light. About half the light goes through reflected on the second mirror and then comes to a screen.

The other part of the light is up and back down. So the light either travels against the aether wind or perpendicular to the aether wind. If aether is the medium in which light travels, then the velocity needs to change. The velocity of light in this medium will change. If there is no aether wind, there is no change in the velocity of the light.

The result of the experiment is an interference pattern on the screen. The experiment is called an interferometer. So there are some systematic uncertainties here. There are some unknowns. For example, if you're building your table, it's not really clear in which direction aether actually-- which direction is actually the direction of the aether flow. But you can get by this by rotating the table and making various sets of experiments. And that's what Michelson and Morley did.

I want you to show that the effect they're about to observe-- or they will not observe-- is of the order of v over c squared. And what you want to do is compare the light as it travels on this path number 1 to one mirror and on the second path to the second mirror. So if you're following the video, I ask you to just stop here and figure out how long does it take for the light to travel on this path here-- on the lower path, path number 1, or path number 2.

Well, obviously, I've worked this out already. So we want to calculate the time it takes light to travel path 1 that is going up and coming down-- going left and going right. So in the first case, the velocity is reduced by the velocity of aether. So the time it takes is l1, the leg, divided by c minus v plus the return leg, l1 over c plus v. And you work this out, and you simplify a little bit, you get this first equation.

For the second part, the one up and down, you want to draw this triangle here to figure out that t is equal-- the time it takes is equal to the square root of l square over c square minus v square. And then you simplify again, you get this [INAUDIBLE] square root [INAUDIBLE].

What's important is the time difference for the light traveling with two legs. And we find that the time difference t1 or t2 minus t1 is given by this bit complicated looking equation. So now in the experiment, you want to set up l1 equal to l2. To simplify, you might not be able to do it very precisely.

What you can do, however, is rotate the table. If you rotate and then compare the difference of the differences, you find that here there's this v square over c square dependence. I used a little trick to simplify the square root as I use this 1 plus or minus x to the nth power. It's about 1 plus minus n times x for x plus 1. And since the velocity of aether is presumed to be small compared to the speed of light, that's a good approximation.

The result of the experiment was there was no effect. They tried-- they improved the experiment. They tried to find smaller effects. They didn't find any. The reason for this is that there is no aether. But we can use this now to make a case against the aether.

But you could say that maybe they didn't observe anything because the aether is dragged with the Earth. So instead of the Earth going through this aether, and therefore, we experience aether winds, you could argue that maybe aether is localized around the Earth, moving with the Earth or maybe moving with the universe. And so in the next video, we'll look at a case against that scenario as well.