MARKUS KLUTE: Welcome back to 8.20, special relativity. In this section, we want to talk and investigate a bit more length contraction. We have seen length contraction a few times already in this class. We have derived it. We have seen it in application. But we want to get some sort of feeling to how can we actually understand what's happening to the objects. Later in this section, in this video, we'll talk about another paradox, spacecraft on a rope. So let's get to it.

So the situation here is as we have seen a few times already. We have Alice being at rest, and Bob is moving with a velocity v. And what we are interested in is this object here, which might be a rod of some sort. You can think about a spacecraft if you want, but a specific object, which, at rest, has a length LB. For Alice, this object is Lorentz contracted, and it appears shorter.

So now what happens now if Bob accelerates from his velocity v to a velocity v plus delta v with respect to Alice? How does the acceleration occur? And how can we understand then the further shrinking of the spacecraft?

Bob tries really, really hard to accelerate such that all elements of this rod or spacecraft are being accelerated simultaneously in his framework. You can think about splitting up the spacecraft into small elements. They're all getting a little bit of a kick, a little bit of an extra momentum at the very same time.

So, if now Alice observes the same situation, we find that she looks at the spacecraft. And, because the leading clock in the spacecraft, in Bob's spacecraft, lags, she observes that the spacecraft's back is being accelerated first. And, because it's accelerated first, she observes that the spacecraft shrinks just a little bit because of the additional velocity. Well, that's kind of an interesting picture to think about how we can understand length contraction and how we can understand length contraction once there's acceleration involved.

OK, so the next question now or the next topic here in this video is the spacecraft on a rope paradox. This was phrased by Bell in the 1950s and '60s. He was working at CERN at the time and roaming the corridors, discussing with his colleagues.

The situation here is related to the one we just discussed, but slightly different. So let me explain. So again we have Alice as an observer, observer in a reference frame A, observing two spacecrafts. They are identical spacecrafts. They have the same engines. And they are separated by distance D.

So now Alice gives a signal to both spacecrafts simultaneously in her reference frame to accelerate at the same time such that the distance between B and C remains constant. So they're asked to accelerate such that the distance remains constant.

Well, the question now is, when those two spacecrafts are connected with a rope, will this rope break? So I'll let you think about this a bit and come up with your own answer.

In the meantime, this is not such a hard problem actually. In order to keep the distance constant for A, the distance in the BC reference frame, in the reference frame of the two spacecrafts, needs to expand. So LA, so the distance as observed by Alice or reference frame A, is equal to 1 over gamma, the distance between the two [? planes. ?] And for this to stay-- for LA to stay constant while there's acceleration going on, LBC needs to increase. That's why the rope will break.