

MARKUS

KLUTE:

Welcome back to 8.20-- Special Relativity. In this short video, we look at the historic backdrop, the time in which Einstein was able to develop the theory of special relativity. What were people thinking? What was the physics landscape of the time?

How was technology developed? And how did all those things come together for Einstein to thrive and come forward with those important discoveries in physics? We have to go back to 1900, around that time in which Einstein was able to break through, break out, and come up with completely new ideas in physics.

Before we go into the discussion of the timelines, I'd like you to be invited to come to Geneva, to Switzerland, to Bern, to Zurich-- to the places in which this all happened. Especially Bern is a historic town, wasn't destroyed in the Second World War. And if you walk down the streets, here is a picture of me two years ago in front of the Einstein house. The streets are basically unchanged for the last 150 years, so you look up into the window, and you see Einstein looking down at you.

So if you go back 200 years, in Italy, people like Volta and others started to make use of electromagnetic effects. The first batteries were developed. And a theory, a wave theory of light was developed. That then let-- slowly developed into the theory of electromagnetism and the understanding of those phenomena.

And the very same time, in Europe, the first railroad systems were developed. Electromagnetic induction was understood. And then in the 1860s, Maxwell was able to put all of those concepts together in his famous Maxwell equations, which are discussed at length in 8.02.

People were then, because of the railroads but also because of telegraphic cables, able to communicate and move over a larger distance in a shorter amount of time. And that led to the need of synchronizing clocks. To that point, in each town had one or a few clock towers. And you just read off the time, and it was the time of day. There was no need to be able to tell what time is it in London when you have your breakfast in Munich or what time the store opens in a different city. There was no need for this kind of synchronization.

But with the expansion of railroads, specifically, there was a need to understand when a train when a train is on a track and such that it doesn't intersect with another train, avoiding collisions. You also want to know when you have to be at a train station in order to catch the train. Those things became important, and they led to patents filed around this time and also later on.

On the theory of light, people developed all kinds of ideas and conflicting ideas of, for example, mechanical models of light, which relied on the existence of a medium in which light travels. And we'll discuss this at length.

In the 1880s, there's a new phenomena in the structure of physics. Up to this point, there was a professor of physics at an institute. He had a chair, and everybody was working for them. But then there was a change in the way physics research was conducted, such that there started to be a division of labor between experimental physicists and theoretical physicists.

Around this time, Thomas Edison developed light bulbs, meaning that light and electricity, those two things became more woven together. Electromagnetic waves were discovered. And Michelson and Morley conducted the experiment. And they did not find a medium which carried light waves.

And we'll discuss the Michelson-Morley experiment in much more depth. But this was basically the backdrop. Michelson and Morley-- the idea of electromagnetic waves, how do they actually travel. What is the speed in which they travel? What are the medium? And how does this all interact?

So Einstein was born into this. He was born in Ulm, a German town, a small German town, on March 14, 1879, on Pi Day. He spent his youth in Munich, where his father-- he had an electrical company, a company which provided electrical services-- for example, for the Oktoberfest in Munich. And his business went up and down and had to be relocated later into Italy. It was a difficult and interesting time.

So Einstein went to school in Munich, in a gymnasium in Munich. And at some point, it was time for him to go to military service. And he avoided this by becoming stateless. He then wanted to enroll in a university in Switzerland, Polytechnic of the Eidgenössische Technische Hochschule in Zurich. But he wasn't quite admitted, mainly because his French wasn't quite sufficient. So he had to go an extra round of studying in order to be then admitted to the Polytechnic.

One of his mentors at the time was Herr Professor Weber. He was a leading physicist there. And they had an interesting relationship, which I come back to in a little while. While studying in Zurich, Einstein met his wife, Mileva Maric. She was also a physics student, one of the few female physics students there. And they fell in love, and they married. And they had a child together, or children together.

In 1900, Einstein graduated. He wasn't the best student in class. Neither was Mileva Maric. And he had a hard time finding a career. So he wanted to stay at the university and enter an academic career, and that required the mentors to be in favor of this. And since Einstein didn't quite develop a good relationship with Herr Weber and the other professors around, they didn't want him there. They didn't promote his career.

So he didn't know quite what to do-- went back to his parents, to Italy, and didn't get any traction from where he was. And he was quite anxious about this, which is visible in letters he wrote. But he had good friends there. He had a good friend, Marcel Grossmann, specifically, who helped him get into, after some back and forth, a position as a lower level patent clerk in a patent office in Bern.

And so this was the starting point for a career. So he had this-- he was a patent clerk. He had a lot of time on his hands beyond that. And that started something which was called the Olympia Academy, which consisted of a group of people who studied with and friends of Einstein, including Marcel Grossmann. And they talked and spent time, took long walks, spend time drinking, partying, if you want, but specifically talking about physics. And in this framework, Einstein was able to develop this ideas.

And then 1905 came-- not in a sudden, but in 1905, he was able, out of this context, to develop five very, very important papers. The first one was on light quantum. He was able to describe the emission and absorption of light. In April, then, which was part of his PhD thesis, he was able to characterize the size of molecules.

And in May, he was able to show the existence of atoms. He was basically demonstrating this by following Brownian random motion of atoms. And then in June, he wrote a paper named electrodynamics of moving bodies. And that is the paper in which he discovers or describes special relativity. On further review, he discovered that there's a consequence of special relativity that energy and mass are equivalent in his famous equation $E = mc^2$. And we'll come to this, as well.

So this is basically the framework of this lecture. If you then move forward into general relativity, which was developed by Einstein in 1915, you can then, again, follow the development of signs of quantum mechanics of general relativity and the conundrum of describing those two concepts at the very same time, in which, then, Einstein lived and moved.

His career developed then from there on, not instantly but systematically. He had a call as a professor in Berlin later on and, after the Nazis took over in Germany, decided to flee Germany. And he moved to the United States, where he took on a position in Princeton. The rest is history, as you want, and we'll hear more about this tomorrow.