NICHOLAS DIBELLA: Hi. Welcome to Excitatory Topics in Physics. Has everybody gotten a syllabus? OK, good. Well, if you haven't gotten it, you can just get it after class.

My name is Nick DiBella, and I'm a junior physics major here at MIT. I'm from Florida, originally from New York. And I love physics and pizza. And I think that's all you need to know.

Well, so excitatory topics in physics, what is this class all about? What does excitatory mean? Have any of you even heard that word? Well, excitatory basically means exciting. I could have easily called the class Exciting Topics in Physics, but I think the word "excitatory" adds a little bit of mystique to the class and makes it a little more interesting, maybe. Well, anyway, you could look up the word "excitatory." It's actually a real word.

So the goal of this class is basically to entertain you all. And I hope to do that by telling you about some of the most interesting things that I've ever heard in physics-- well, the most interesting things that I've heard that I can understand. Because I've heard a lot of interesting things that I don't understand, and I can't tell you about that. I'm sorry. Hi.

As you've probably read from the course description, I plan for this class to be as conceptual as possible. And the main reason I've decided to do that is because it's really the ideas of physics that are exciting. Of course, to really write down the laws--

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: Don't worry. That's OK. To really describe the universe, you have to use math. There's simply no other way to do it. You can't be precise. You can't really describe the universe without using math.

But equations themselves don't really mean anything. It's the interpretations that we give to the equations that are meaningful. And it's those interpretations that are interesting. And it's those interpretations that I'd like to talk to you all about for these coming weeks.

Now, I will, a few times in the class, pull out an equation just to impress you all, but no-- pull out an equation that you can appreciate and that you can actually use. But they won't be complicated. Probably if you just know algebra, that's enough. But there will be a few times when you'll be able to enjoy these equations that I'll give you. You'll be able to enjoy them.

Oh, another reason, by the way, that I wanted to make this a qualitative class was so that I can get as many of you here as possible. And, well, it's good to see so many of you here.

Now, the way this class will work is we'll meet here Sundays at 1:30. Today's the only day we're meeting at 2:30. We'll meet here Sundays at 1:30 and go until-- well, 1:30 PM, 1:30 PM. And we'll go until 3:00 PM. Technically, we'll go from 1:35 PM to 2:55 PM because that's the way MIT always does these classes.

And we'll meet in this room, as usual. And we'll have a short break about an hour into the class, maybe 4 and 1/2 minutes or 5 minutes, something like that. And then we'll continue.

And then there's another class meeting right afterwards, so we have to get out of here when I finish. But if any of you guys have questions, I'm happy to talk to you guys after class. I mean, you could follow me around, or I could follow you around, or wherever.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: No, not going to follow you around. Sorry. I'm not going to follow you around. You can follow me around. You can follow me around and just ask any questions you have. I'm very happy to talk to you all.

As you can see in the syllabus-- so you can see in the syllabus my name is Nicholas DiBella. You can call me Nick. You can email me with the email address that's listed right there. And you can feel free to call me as well if you have questions.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: No. I really-- oh, sure. Sure, yeah. The rest-- here. You can get it after class if you don't already have it. You can get the syllabus after class if you don't already have it.

But I love questions, and I love listening to questions. And I hope you guys feel the same. Oh, by the way, during lecture, you can feel free to ask questions if I said something confusing or if I'm going too fast, or if I'm mumbling. But try not to ask a question once every minute. Because then, we kind of lose the flow to the class.

Are there any questions about how the class will work or anything like that? OK, good. So now that we've-- OK, good. Now we can get to some physics.

OK, so let's get to the physics now. Well, I just want to make sure there's no doubt in your mind as to what physics actually is. Physics is the branch of science that attempts to explain everything-- every atom, every molecule, every insect, every dog, every cat, every person, every planet, every galaxy, every bit of energy, everything that's out there, everything that's out there that's observable. Well, I say observable because things that aren't observable aren't part of science. And that's just by definition.

Now, physics-- well, physics which is the body of laws that describe everything-- well, physics is this collection of laws that describes what can happen and what can't happen. Just to give you an idea of a law of physics, there's a law of physics that says you can't travel faster than light. Light's the ultimate speed limit.

Now, I can think, in my mind, of theoretically traveling faster than light. I mean, going on my bicycle and just going-- well, maybe a rocket ship. Going on a rocket ship and going really, really fast, looking at the speedometer and seeing it pass the speed of light, I can imagine that. But just because I can imagine that doesn't mean it can happen because it violates a law of physics-- namely, the law that says you can't go faster than light. And so we're trapped in this world where some things can happen, and some things can't.

Now, humans have been around for kind of a long time, but it wasn't really until the 1600s or so that we began to make much progress in uncovering these laws of physics. And there's a big name that you probably all know. And it was Sir Isaac Newton that really started this revolution in our understanding of the world.

He proposed three laws, which you all know as the laws of motion. He discovered a law for gravity, and he did a lot of other things too. But he really set the foundation to what we now refer to as classical mechanics.

Oh, you guys don't have to take notes, by the way. You could if you want, but you don't have to-- classical mechanics. And by the way, I wasn't encouraging you to take notes by that comment. I was just trying to clarify something.

Classical mechanics, this was Newton. And that was in the 1600s or something like that. It doesn't matter. Well, it does matter that it was a long time ago, but it doesn't matter so much about the precise century, 17th century.

Now, we call it classical just because it was from way back when. Like, we refer to classical music, a long time ago. Classical mechanics describes how everyday things work. It describes how this table will move if I start to push it. It can describe how friction works, friction between the ground and the leg of the table.

It describes how an object will move if I throw it. Like, if I threw my cell phone, you would know. Classical mechanics predicts, with its equations, which I won't talk about, but it predicts, with its equations, for, instance that the motion of my cell phone is something like this. If this is height, and this is time, it moves something like that. It makes this definite prediction about the trajectory of my cell phone.

And it's exactly what you see. And classical mechanics is enormously successful in predicting the motion of everyday things. And not only does it predict the motion of everyday things, but it also predicts the motion of, I guess, every-night things, like the planets, the planets moving around the sun.

It makes these very definite predictions, and they're confirmed extremely well by what we observe when we look through a telescope in the sky. Or if you look in the sky with your eyes-- no, I don't know how good our eyes are. But if you look at the sky with a telescope, then you can see the motions of planets and stars. And classical mechanics is amazing at predicting how these things move.

Now, in the 1600s and 1700s, we had classical mechanics. And so we could describe everyday things. But, well, what about some kind of everyday things that aren't extremely everyday things, like electricity and magnetism, lightning, rainbows?

Well, it was really the 1800s that we started to uncover these laws of electromagnetism, electricity and magnetism. And people did tons of experiments to figure out how these forces worked. Newton really figured out gravity. And electricity-- well, people in the 1800s were working on electromagnetism.

And the main name that's associated with electromagnetism is James Clerk Maxwell, who figured out a puzzle in electromagnetism that was kind of troubling. He figured out this key component that you really needed to really understand electromagnetism. And then he really unified the whole theory.

And so today, we refer to Maxwell's electromagnetism as classical electromagnetism. And that was Maxwell. This was the 1800s. Oh, whoops. I just realized I'm not supposed to write on this board. Oh, well.

Now, electromagnetism as Maxwell formulated it, these people figured out, also works extremely, extremely well. I mean, it's just as good at describing the things that it describes as classical mechanics is at describing the things that it describes, if that makes any sense.

And so by the end of the 1800s, people were so confident in these theories because they described pretty much everything that they could think of. And they were able to describe these things with such amazing accuracy. And there was a feeling, at the time, a growing feeling among physicists, that we had solved physics. We had figured it all out.

But there were a couple problems. There were a couple of problems with the theories that had to be fixed. There were problems between conflicts of these two, mechanics and electromagnetism. There were conflicts in things they predicted.

Well, one of these-- well, it wasn't a con-- well, I guess, one of these problems that had to be fixed was called-- well, one of these problems we now refer to as the ultraviolet catastrophe. I'll explain it in a second. Let me just write it down. The ultraviolet-- doesn't that sound really bad, ultraviolet catastrophe.

We call it catastrophe because it was so bad. And ultraviolet because-- well, let me explain first before I tell you why ultraviolet. So according to the physics of the time, which was-- well, I don't think they called it classical mechanics back then.

But according to Newtonian mechanics and according to Maxwellian electromagnetism, the theories predicted that if you turn on a microwave, then there would-- well, one of the things that they predict is that if you turn on a microwave, then there would suddenly be an infinite amount of energy inside of it. And that seems odd, right-- infinite amount of energy inside of a finite box?

Well, this type of energy, which, when you calculate it, it ends up being infinite, is electromagnetic energy. And one of the more energetic forms of electromagnetic energy is ultraviolet energy, part of the ultraviolet part of the electromagnetic spectrum, if you've heard of that. And so we call it the ultraviolet catastrophe.

I guess you could also call it, like, the X-ray catastrophe, or the gamma ray catastrophe, or anything else, because those are actually more energetic than ultraviolet. But if those words don't mean anything to you, then don't worry about that.

So, well, I haven't really defined energy, have I? Now, I haven't define energy for you guys yet. Well, I'm not going to define it precisely, but you all have some kind of idea of what energy is. Probably the most familiar type is kinetic energy, the energy of motion. If I run fast, then I have a lot of kinetic energy.

You've probably also heard of potential energy-- specifically, gravitational potential energy, which is the energy that you have when you're in a gravitational-- well, when you're around something that has mass. So the higher up you go, the more gravitational potential energy you have. The lower you are, the less gravitational potential you have.

Now, one of the things that physics allows is energy conversions from one type to another. So for instance, potential energy can be converted to kinetic energy. And you all know how this happens.

Say you go on a plane. It starts flying up, and then you jump out of the plane with a parachute, jump out of the plane with a parachute. At first, you're very high up, and you have a lot of gravitational potential energy. But you're not moving very fast.

And when you jump out, you start moving faster. And then you eventually get faster and faster and faster. And so eventually, a lot of gravitational potential energy gets converted to kinetic energy. And so that's a very simple type of energy conversion.

Now, I want to tell you why the ultraviolet catastrophe's bad. I mean, just because there's an infinite amount of something doesn't necessarily mean it's a bad thing. I'll just give you an example why infinite doesn't necessarily mean that. A priori, it doesn't necessarily mean bad.

Because, I mean, this room is finite, right? There's a finite amount of space in here. But there's an infinite number of points in it, infinite number of points of space. So there's an infinite of something in a finite amount of something. So why's it bad with energy?

Well, it's actually very-- well, there are a lot of obvious reasons why it's bad. But actually, I was thinking about why it's bad when I was preparing this lecture. And I realized that the books that talk about this don't really talk a whole lot about why infinite energy in a box is bad. They just say, well, of course it's-- so when you calculate this, when you perform this integral, when you calculate this, you get an infinite amount of energy inside the container. And that's all they say.

Or they'll say, which clearly violates experimental observation. OK, well, yeah, sure. But what about those of us for whom it's not completely clear? I mean, we should be able to understand this very simply.

I mean, OK, you could understand it by saying, OK, well, it's clearly contrary to what we see. You could say that. But from a physics point of view, why is it bad?

Well, one reason why it's bad is that, well, all those electromagnetic energy stored inside of the microwave or inside of this box gets converted into kinetic energy of the atoms moving around. And so these atoms pick up this energy, and start moving faster and faster and faster. And eventually, they have infinite kinetic energy, and they'll break the container.

And you don't-- I mean, you see microwaves. Microwaves exist. Microwaves exist, although I guess I am kind of using now, well, you don't see the fact that microwaves explode. So I am kind of using the "it goes against observation" argument. But, well, you could interpret what I just said as a proof that physics, at the time, proves that microwaves today cannot exist, OK?

Now, this was a problem. This ultraviolet catastrophe was a problem for a while before someone figured out how to fix it. And it was Max Plank that figured it out. Or you might have heard of Max Planck. I don't know. I hear both pronunciations. It's just a name.

Max Planck is the one that fixed it. He came up with this awesome idea of how to fix it, and it worked. And it actually-- it's a K. Max Planck fixed it. Sorry. But that's-- I was trying to draw a smiley. Remind me never to draw a smiley ever again on a chalkboard. OK, how's that-- fixed it.

And this eventually led to the development of what's called quantum mechanics. It's just one of the steps leading up to the development of quantum mechanics.

Now, I don't plan to talk more about quantum mechanics until a couple of lectures. Well, I don't plan to talk more today about quantum mechanics because I'm going to do a whole lecture on it in a few weeks, or something like that. So I'll just let you ponder what it could possibly be. Quantum mechanics, what could it be? I'll let you think about that.

Anyway, quantum mechanics, the development of quantum mechanics was one of the two major developments-- yes?

AUDIENCE: So what did Max Planck fix again?

NICHOLAS DIBELLA: He fixed-- he inserted something into the theory that made it so that the ultraviolet catastrophe wouldn't happen. He allowed microwaves to exist. Well, what he actually--

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: Well, what he did was he introduced the idea of the quantum, that light comes in individual chunks called quanta. And when you add this into the theory, it turns out that everything is fixed.

And Planck actually didn't really have a physical motivation for that. It was more of a mathematical trick that he was able to fix the theory. But it was Einstein afterwards that recognized there was something deeply physical about this and deeply important. But I'll get to that in a few weeks. So I'll let you guys have dreams or nightmares about the ultraviolet catastrophe and how it's fixed for the next few weeks.

Now, quantum mechanics, as I said, was one of the two major developments in modern physics, which is the physics of the 20th century, 20th century. Now, I realize we're in the 21st century. So maybe what we do today is also called modern physics. Maybe postmodern would be a better word. Like, you have postmodern arts, postmodern architecture, and things like that. I don't know-- modern physics.

Now, quantum mechanics was one of the two, one of the two major developments in modern-- quantum mechanics was one part. The other part was relativity. And relativity was Einstein's baby. Einstein was pretty much the one who figured it all out.

Now, how much time do we have? OK. Now, relativity was necessary because these two theories, Newtonian mechanics and Maxwell's theory of electromagnetism, these two theories were ultimately at odds with each other. They couldn't both be true. Only one of them could be true, or none of them. But at most, one of them could be true.

And how many do you think Newton was right? How many of you think Maxwell was right? You can vote. I mean--

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: Well, it turned out that it was actually Maxwell that was right. And so Newton's mechanics had to be fixed. And how to fix it? How do you fix it?

Well, this is what Einstein figured out in the early 1900s. And he wrote a paper in 1905 called "On the Electrodynamics of Moving Bodies," where he, in one paper, completely set the groundwork for special relativity.

Now, special relativity is one of the two main parts of relativity theory, which I'll write over here. Relativity has a special part. Well, I guess that "part" might not be the best word to use, but I'll just say part. There's special theory of relativity. It's one branch of the whole theory, special relativity. And there's the general theory.

Now, special relativity Einstein figured out in 1905, but it took him another 10 years or so to figure out general relativity. Now, general relativity is a theory that modifies Newtonian mechanics by-- well, both of these theories fixed Newtonian mechanics. They both fix it in a certain way.

Special relativity fixes it if you're living in a universe where there's no gravity. General relativity fixes it if you're living in a universe where there is gravity. And so clearly, we need general relativity in the real world.

Now, it turns out that general relativity is a lot harder to understand than special relativity. At least mathematically, it's a lot harder to understand, which was one of the reasons it took Einstein a long time to figure out how to do it. So I'm going to start with special relativity today.

And special relativity really has only two laws to it, two postulates. There are two postulates of special relativity, which, when you use them, you get everything. And there are a lot of things that you can get from special relativity.

Let me just write down these two postulates. Well, actually, there's something I wanted to say before. Going back to modern physics, just going back to the whole thing that was figured out in the 20th century, it's important to understand that these new laws of physics, these new theories, were completely crazy, really. They're crazy.

And there's a notion among the unscientific people of the world that relativity and quantum mechanics are confusing and crazy and mysterious. And that's because they are. But it is possible to understand them. There's a notion that's impossible to understand, but you can understand them. But they are crazy.

And just to give you an idea of how crazy they are, I want to show you an experiment. I want to do a little experiment for you. One of the things that quantum mechanics predicts is that there is a chance that I can walk through the wall. So if I walk through the wall right now, then that would be evidence that quantum mechanics is right. So let me try to walk through the wall, OK?

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: So let's see. Shall I try this one, or shall I try green? I'll try--

AUDIENCE: Green.

NICHOLAS DIBELLA: Green?

AUDIENCE: Green is more [INAUDIBLE].

NICHOLAS DIBELLA: Green is what?

AUDIENCE: More [INAUDIBLE].

NICHOLAS DIBELLA: What's that?

AUDIENCE: [INAUDIBLE]

AUDIENCE: Run.

AUDIENCE: Run.

NICHOLAS DIBELLA: Oh, I'm going to walk into the wall.

AUDIENCE: Try again.

NICHOLAS DIBELLA: Well, OK, I'll try one more time. OK, well, I just tried it three times. I just tried it three times, and I didn't walk through it. Oh, did anybody see me walk through it, though? I'm not sure if I walked through it. Did I walk through it? No?

AUDIENCE: No.

NICHOLAS DIBELLA: OK, OK. Well, according to quantum mechanics, there's a chance. There's a non-zero probability that I can walk through it. But it turns out that that probability's actually something like 10 to the minus 50th. So that's a 0.0, 49 zeros, and then a 1. So I have to attempt to walk through the wall a billion billion billion billion billion million times before I finally will probably walk through.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: And so that's actually evidence that quantum mechanics is right, because I didn't walk through the wall with three tries. You wouldn't expect it to take three tries. You would expect it to take a billion billion billion billion million times, or something like that.

Oh, by the way, that probability is actually increased when I increase my kinetic energy. So if I try running into the wall, then there's a greater chance that I'll actually go through it. Should I try that?

AUDIENCE: Yeah.

NICHOLAS DIBELLA: OK, OK. Let's see.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: Oh. I hope I didn't-- OK. I hope I didn't break my microphone or these equipment. But yeah. But if I did go through it, wouldn't that be amazing if I actually did go through it? I've probably tried walking through the wall hundreds of times, and I've never been able to go through it.

And it would have been amazing if we could capture this moment on video because I claim to people many times that I can do it, and they don't have confidence in me. But I think I can do it. And it would have been cool if I could have done it. I'll try it again some other time, maybe. Yes?

AUDIENCE: How did they come up with that? Is that really the chance of it happening?

NICHOLAS DIBELLA: Oh, how did they come up with it? I haven't done the calculation in a while, but you can do a simple one-dimensional quantum-tunneling calculation to get it. If you know some quantum mechanics, I can show you after class how to do it. OK.

AUDIENCE: What if you only went halfway through the wall?

NICHOLAS DIBELLA: Then I'd have a lonely life afterwards. Yeah, it's one of the mysteries of quantum mechanics. Well, one of the really cool things is this phenomenon called quantum tunnelling, and I just love it because it makes so many things possible. It makes it possible, for instance, for me to fly across the room. There's a chance I can do that. I haven't done it yet, but there's a chance I can do it. Yeah?

AUDIENCE: If it's possible to run through the wall, then isn't it possible for you to fall through the floor?

NICHOLAS DIBELLA: Yes.

AUDIENCE: And there are 6 billion people in this world. And they're supposedly trying every second to fall through the floor. So that would break that absolutely. You'd have to try so many times to fall through the floor.

NICHOLAS DIBELLA: Actually-- well, I haven't really told you, though, the full story. Real materials are actually a little bit more complicated than how you might calculate this probability. It's actually the Pauli exclusion principle that kind of saves us. It kind of saves us from falling through the floor.

But because-- well, real materials are made up of electrons and protons and other kinds of particles that are called fermions. And there's this rule called the Pauli exclusion principle that applies to them. And it says that you can never be in the same quantum state as these particles, and that actually makes this probability a lot lower and makes me sad because--

AUDIENCE: [LAUGHTER].

NICHOLAS DIBELLA: But yeah, the probability is actually much lower than that because of the Pauli exclusion principle. But I might talk more about the Pauli exclusion principle in a few lectures, but I might not. But if you're interested about it, then talk to me.

So quantum mechanics is really weird. That's one of the weirdest things about quantum mechanics, that it allows so many things to happen. Relativity is also really weird. First, according to relativity, I'm aging at a slower rate than the people in the back of the room.

AUDIENCE: What?

NICHOLAS DIBELLA: Yeah, I'm aging at a slower rate than the people in the back of the room.

AUDIENCE: Why?

NICHOLAS DIBELLA: Why? Because of gravitational time dilation, which I'll tell you about next lecture.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: Well, I could tell you more crazy things, but I should probably get to telling you about special relativity. By the way, that effect that I just told you about comes from general relativity. You also get lots of cool things from special relativity.

But you I'll tell you about them in due time because first, I want to talk about special relativity, and then I'll talk about general relativity. Then I'll talk about quantum mechanics. Then I'll tell you about everything. I'll give you the theory of everything, maybe. And I'll tell you things that people are working on, and some really, really cool ideas.

So I just wanted to tell you how crazy modern physics is. It's totally crazing, mind-blowing. You can't sleep. Once you learn this stuff, you'll never sleep again, ever, ever, really.

So special relativity-- I want to tell you about special relativity. Special relativity has only two postulates. You might be familiar with the term postulate from geometry class or something like that.

AUDIENCE: Oh.

NICHOLAS DIBELLA: There are-- OK. You don't have to do any geometry for me if you don't want to. I'm not going to force you guys to do geometry if you guys have bad memories, nightmares from classes.

But there are two postulates of special relativity, postulates that you can't prove. They're simply fundamental to the theory. You can't prove them. You simply can't prove them. And I'll tell you what they are, the two postulates of special relativity.

The first is that the laws of physics are the same for everybody. It's a fair world. Nature is kind to us. The laws of physics are the same for everybody. Now, I put "everybody" in quotation marks because I'll have to be a little bit more precise what I mean by everybody.

The second postulate is that the speed of light is-- yes?

AUDIENCE: What do you mean by everybody?

NICHOLAS DIBELLA: Yeah, I'll tell you in one minute.

AUDIENCE: Because what happens if you're fatter?

NICHOLAS DIBELLA: OK. Well, it's been said that--

AUDIENCE: Will it change?

NICHOLAS DIBELLA: Well, it's been said that we're all equal, but some of us are more equal than others.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: I'll be more precise in one minute. Just wait a second. The speed of light-- whoa. Oops. The speed of light-- whatever. The speed of light is the same for everybody. Clumsiness isn't.

Now, here's what I mean by everybody. By everybody, I mean all inertial observers. What does inertial mean? Inertial means moving at a constant speed. I'll write it down. I'll write it down. Moving at a constant-- sorry for my handwriting, by the way, if it's awful. I think it's awful. Inertial means moving at a constant speed.

So if I walk across the room at a constant speed and walk over all the chalk that I knocked over, then I'm an inertial observer. An observer is simply somebody that makes measurements or a device that makes measurements. So yes?

AUDIENCE: Do you mean speed or velocity?

NICHOLAS DIBELLA: Velocity. But if you're moving at a constant velocity, then you're necessarily moving at a constant speed.

AUDIENCE: Right. But if you're moving at a constant speed, you're not accelerating.

NICHOLAS DIBELLA: That's true. OK, so if I started to accelerate, then I wouldn't be an inertial observer. And in that case, special relativity just wouldn't apply.

It turns out that observers that are accelerating are complicated to deal with. And you actually have to use general relativity if you want to make measurements while accelerating. Because, well-- and this is actually really big, what I'm about to tell you.

It turns out that there's an intimate connection between acceleration and gravity. And Einstein called it the happiest moment of his life when he figured out that that was true. I'll leave that for you to think about for a week. I'll tell you about it next week or the week after, something like that.

Now, the first postulate is easy to accept. We all get the same laws of physics. That's cool. The second postulate, though, is crazy. It's crazy. And to show you just how crazy it is, I need a volunteer.

Sir, what's your name?

AUDIENCE: Lyf.

NICHOLAS DIBELLA: Life?

AUDIENCE: Yes.

NICHOLAS DIBELLA: What a cool name.

AUDIENCE: Thank you.

NICHOLAS DIBELLA: OK. OK, can you walk for me just a little bit? I just wanted to make sure you're a suitable-- well, that you're working experimental apparatus because I'm going to use you as an experimental apparatus.

AUDIENCE: [LAUGHTER]

NICHOLAS I'm also going to use myself as an experimental apparatus. We're just going to walk across the

DIBELLA: room. Here, come with me. We're going to walk from here until the end. And I want you to walk at about half my speed, OK?

AUDIENCE: OK.

NICHOLAS DIBELLA: OK. So let's see. So slow. Finally. OK. Oh, give me a few more minutes, a few more minutes.

OK, that was fine. Let's just do it one more time, OK? Let's do it one more time. Good job.

Now, let's see. Oh, come back up. Come back up. Oh, I wanted to write on there, but I guess I'll have to erase something. Now, your name is Life?

AUDIENCE: Yes.

NICHOLAS DIBELLA: L-I-F-E?

AUDIENCE: L-Y-F.

NICHOLAS DIBELLA: L-Y-- oh, that's still cool.

AUDIENCE: [LAUGHTER].

NICHOLAS DIBELLA: OK. Now, class, how fast would you say I was walking?

AUDIENCE: 3 miles per hour.

NICHOLAS DIBELLA: 3 miles per hour?

AUDIENCE: Yeah.

NICHOLAS DIBELLA: OK, let's say 3 miles per hour. So the class measured--

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: What? Oh. OK. I failed spelling. Class measures three miles per hour for Nick. My name's Nick, by the way. I think I told you-- for Nick. And how fast would you say Lyf was walking?

AUDIENCE: 1.5.

AUDIENCE: 1.5.

NICHOLAS DIBELLA: I don't think it was-- I think he was actually going a 1. No, maybe 1-- actually, I think I was going 3.5. But OK, let's say he was going 1. Well, let's say he was going at one mile per hour. Let's just say that. Now-- for Lyf.

Now, Lyf, how fast would you say I was walking relative to you?

AUDIENCE: Five miles per hour.

NICHOLAS DIBELLA: Well, I was probably walking slower than that, right? I was walking slower than what they would see because you're already going at 1 miles relative to them. I'm going at three, so probably something like two because I'm going a little bit slower, right, relative to you?

AUDIENCE: Relative?

NICHOLAS DIBELLA: Yeah, relative--

AUDIENCE: Relative to me, yes, you would be two miles per hour.

NICHOLAS DIBELLA: Yes. Lyf measures 2 miles per hour for Nick. And how fast would you say you were walking relative to yourself?

AUDIENCE: 0.

NICHOLAS DIBELLA: 0, right?

AUDIENCE: Yeah.

NICHOLAS DIBELLA: Were you actually doing something like this?

AUDIENCE: No.

NICHOLAS DIBELLA: I wasn't watching you.

AUDIENCE: You weren't?

NICHOLAS DIBELLA: Well, I was walking with him. OK, so you were going at 0 miles per hour relative to yourself, because you're just walking. You're not moving past yourself. You couldn't unless you were special in some way, more special than special relativity. 0 miles per hour for Lyf-- like forever, for Lyf. That's cool. That's a really cool name.

OK, so you measured 0 miles per hour for yourself, and 2 miles per hour for me. This, my friends, is relativity at its simplest. It's simply the relativity of speed.

Relativity simply means that some people measure one thing, and some people measure something else. You, sitting down in these seats, measured certain speeds for me and Lyf. And Lyf, as an inertial observer-- we're both walking at a constant speed-- as an inertial observer, measured 2 miles per hour for me, and 0 miles per hour for himself. That's relativity at its most basic.

It turns out that these rules that relate velocity addition, velocity addition and subtraction. You could can get this by subtracting 3 from 2 to get 2. And you can simply get this one by subtracting 1 from 1 to get 0.

These rules actually don't apply for light. They don't apply for light. And well, I don't have that much more time. But you can sit down, by the way, if you'd like. Thanks.

These rules don't apply for light. The second postulate says that the speed of light is the same for everybody. So if I started walking-- let's see. Do I have a flashlight? I don't have a flashlight, but I have a thermometer that makes light.

AUDIENCE: [LAUGHTER]

NICHOLAS DIBELLA: If I walked across the room, turn this on, then you would think I would measure a certain speed for the speed of light. I would measure 186,282.4 miles per second for light. That's good to know for parties, by the way.

I would measure that speed. And you would guess that you would measure 3 miles per hour plus that speed I just gave you. But it turns out that that calculation's wrong. You get the same exact speed. You get the same speed that I measure for light. Everybody gets the same speed. Speed of light is--