Second Thoughts

A Reexamination of Einstein's Theory of Relativity and its Role in Defining the Nature of Time

By Chris Kennedy

During a recent conversation with some friends of mine, I was asked what some of my favorite movies were. After blurting out as many titles as I could think of, I couldn't help but notice how many of them involved courtroom drama. It seemed that for every *Unforgiven, The Prestige* and *Dr. Strangelove* I came up with, I had an *Inherit the Wind, And Justice for All* and a *My Cousin Vinny*. But I didn't get very far before I confessed that my all time favorite is *A Few Good Men,* starring Tom Cruise and Jack Nicholson.

I've often thought that the examination of Albert Einstein's *Special Theory of Relativity* would make a great courtroom drama. Why not? Just imagine what it would be like to watch a physicist on the witness stand, screaming things like "Handle the truth? You couldn't possibly understand it!"

Maybe the court case would center on a high school science teacher who, after further analysis of The Special Theory of Relativity, decides to present it in an entirely different way, and when he does, the state suspends him. He is also arrested and put on trial for teaching material to students that is not endorsed by the representatives of "Official Science." And in order to get his job back, he would need to prove in a court of law that Special Relativity is not a theory based on scientific principles, methods or the existence of corroborative physical evidence.

Why relativity? It wouldn't be much of a story would it? The teacher would be exposed as a crackpot for challenging such a mainstream scientific principle that has been tried, tested and true for over a hundred years. Besides, it was written by Albert Einstein, the Nobel Prize winner that physicists have been using as their definition of the word genius for decades. So, a trial where some schoolteacher thinks he can be critical of one of the most solid theories of all time would be over so fast, it wouldn't have time to be entertaining, right?

Well, not necessarily. It is true that the academic world continues to provide a resounding endorsement of Einstein's Relativity. And if you go to the physics section of any bookstore you will certainly see an impressive percentage of books about Einstein, by Einstein, or compendiums with chapters devoted to how solid a concept relativity is. But in spite of that, shouldn't we at least hear what this teacher has to say about his alleged wrongful termination in connection with his refusal to adhere to the state curriculum?

Okay, so it looks like our story line is in place for the big courtroom scenes. Now we have to worry about jury selection. Who are we going to get? Physicists? They are the only ones who truly understand this stuff, right? But where are we going to find twelve physicists on this planet that haven't already formed an unshakable opinion on Einstein and relativity? Well, why not have nonscientists as jurors? Nonscientists would watch the movie, so it would have to be presented in a way that general viewers understand anyway.

All right, so here's what we have so far: It's the year 2014, and a Chicago, Illinois schoolteacher in his mid-thirties named Joseph Marlor takes a hard look at Einstein's Special Theory of Relativity and decides that he is going to stray from the curriculum and put in his two cents about what mainstream science says about relativity and how his opinion differs and why. Mr. Marlor is then arrested and disciplined to the point of termination for willfully contradicting the state science curriculum and ignoring two previous warnings from the school board. Mr. Marlor, feeling confident that he has a case, hires a high profile, big-shot attorney to defend him. Sounds great, doesn't it? Well, since we are ready to proceed, I will now present to you what I think would be an appropriate opening argument for the attorney representing Mr. Marlor. And since this is my story, I figured I could play the part of the big-shot attorney. The argument would go something like this:

Good afternoon ladies and gentleman. My name is Chris Kennedy and I am the lead defense counsel representing Mr. Marlor in this case of the State of Illinois vs. Joseph W. Marlor. I want to thank you in advance for your service and attention to this matter. In fact, considering that none of you are scientists and you are about to hear a case surrounding Einstein's Relativity – I'm grateful that you all decided to show up!

To get to the point, three months ago my client, Mr. Marlor, while teaching high school physics at Waldemar Voigt Senior High School, was terminated for allegedly straying from the curriculum. My client was accused of presenting specific course content in an inaccurate and irresponsible manner, and after two warnings, he was terminated from his position. He was then arrested, after Dr. Maurice Evans discovered that he was providing students with scientific information that is not approved by the National Board of Official Science. Do the accusations that led to my client's termination say that this was continuous, ongoing behavior? No. According to the school administration, my client presented material on all of the other physics topics clearly and effectively. The only topic my client is accused of not presenting responsibly is the Special Theory of Relativity. What the heck is that, you ask? Well, in order for you to determine if my client is innocent or not, you will need to know what relativity is, right? And if you don't know but have always wondered, you are in for a real treat today!

I myself am not a scientist but I do obviously deal with facts in my business, so we will be looking at relativity from an evidence based standpoint and I trust that you will be comfortable with that too. In order for me to properly present Mr. Malor's case, it is of utmost importance that you understand what we are talking about here and I am very confident that in a short period of time you will.

So at this time I would like to present to you the 375-year-old story of relativity:

In the1630's, in a small suburb of Florence, Italy, a man named Galileo Galeli developed what became known as the Principle of Relativity. Galileo was probably not the first person to marvel at the behavior of moving objects and how they compared to stationary ones, but he was certainly the first to engage in such extensive observations and publish such firm conclusions.

Essentially what Galileo concluded was that all the laws of physics are the same in every free-float reference frame. So, what the heck does that mean? The easiest way for you to grasp this simple concept is to first understand the difference between acceleration and constant velocity. Acceleration is when you are sitting at a stop light, the light turns green, you put your foot on the gas pedal and you steadily *increase* your velocity. During this time period, you can tell that you are moving. You can feel yourself being pushed against the seat as your velocity increases from zero to 40 miles/hr.

Constant velocity, on the other hand, is the time period *after* you have reached 40 mph and you are just cruising along, no longer changing your speed. If the ride is smooth enough, someone in the backseat could be reading a magazine and forget that they are in a moving vehicle. If they are traveling 40 mph on a very smoothly riding train with the shades covering the windows, it not only would be tough to determine if you are moving without peeking through the shades, but Galileo (who used riding in a boat for his examples) said that in fact, this would be impossible to determine. Why? Because at a constant velocity, the train has become *a free-float reference frame*. Still wondering what that means?

Okay, how about if we look at it this way. Have you ever seen a hockey puck sliding on the ice? If there were no friction (or wall to run into) the puck would just keep going. Once anything is accelerated to a certain velocity, it actually stays at that velocity until something slows it down. Minimal friction from the ice can slow the puck down, just like wind can slow down objects traveling through the air. Objects often run into velocity stopping obstacles such as walls, baseball gloves, your neighbor's window, or the ground – thanks to gravity. But like it or not, go in outer space and throw a baseball at 70 mph and that baseball will go on forever at 70 mph without slowing down unless it runs into something. Interestingly, what this means in English is that you not only need energy to get something moving, otherwise it will continue to sit there – but you also need energy to change the velocity of something already in motion, otherwise it will continue to move at that velocity! Things simply don't speed up or slow down on their own.

Now, imagine that you bring a baseball on a train with you. The train starts moving - and the train, you, and the baseball all simultaneously accelerate to 70 mph down the track. You along with everything else on the train are now all traveling at a constant velocity of 70 miles per hour. Now here's the fun part:

1) Relative to the train – you are not moving.
2) Relative to you or the train, the baseball isn't moving either.

To test this, you get up and walk around and you move up and down the aisle of the train just as easily as if the train were not moving. You then toss the ball straight up in front of you and the ball goes straight up and then straight back down in your hand. It didn't fly backward or change direction at all. So to put this in perspective:

1) Relative to the Earth and the train tracks beneath you – you the train, the ball and everything else on the train are traveling 70 mph.

But:

2) Relative to the train – You, the ball and everything else in the train are not really moving at all. You are in, for all practical purposes – your own independent, free float reference frame.

Now, after the train comes to a dead stop, is everything on the train no longer moving? Once again, the answer is relative to your frame of reference. If you fell asleep on the train while it was traveling 70 mph and awoke after it came to a complete stop at the train station would you feel the difference? If the shades were still down would you have to peek out the window to see if you stopped? (Of course, this would only work if the train was a very silent and smooth running maglev, but you get the idea.) Are you still moving or not? The answer is: r*elative to the Earth*, you are now in fact motionless, but *relative to the Sun*, you are moving at an incredible 68,000 miles per hour. It's just that we don't feel that velocity even though it is pretty fast, because it is constant velocity.

So Galileo's Principle of Relativity asserts that if you are accelerating, then you are surely moving – but if you are traveling at a constant velocity, whether it be 70 mph or a staggering 68,000 mph, you may legitimately declare that you are moving <u>or</u> stationary depending on your frame of reference. And Galileo's principle essentially states that if you are in a vehicle traveling with constant velocity, and have no view to the outside world, there is no experiment you can perform inside of that vehicle to determine whether you are in motion or not. He considered the laws of physics in a moving free-float frame to be the same as the laws of physics observed in a frame that is stationary.

Is everyone still with me?

Great. And so, the principle of relativity became generally accepted among scientists.

Now, I'm going to fast-forward about forty years into the 1670's. There were these astronomers named Cassini and Roemer and they apparently had nothing better to do than to look at the planet Jupiter with a telescope. In particular, they were studying one of Jupiter's moons (which, coincidentally was discovered by Galileo) and its orbits around the planet. After logging observations several times, it was observed that the moon revolved around Jupiter with a definitive velocity, creating predictable time periods when the moon would disappear behind the planet and reemerge from the back of the planet.

Then after further tracking, something rather curious was discovered. The predictable orbit times were no longer predictable. As time went on, Cassini discovered that the orbit of the moon was running behind schedule. Cassini turned his data over to Roemer, who then continued to track the orbits and made the same conclusion. The clear pattern that developed was that the farther Jupiter was from Earth, the longer delay in the orbits. Roemer knew that the moon couldn't have changed speed but he wondered how it was at times, running several minutes behind schedule. What Roemer realized was that it was the *light* of the moon emerging from the rear of Jupiter that took several extra minutes to reach him at that greater distance!

It was at that moment that Roemer realized that light must travel with a fixed velocity and therefore the longer distance it has to travel, the longer it will take to reach its destination. Roemer reasoned that what he was seeing through his telescope was in fact, images of Jupiter's past and not Jupiter's present. Imagine what he thought when he realized that for the first time. The possibility of this was apparently so mind blowing, that Cassini had actually entertained it as an explanation before Roemer did, but quickly discarded it because of how radical a concept it was. It may seem strange that when we look at far away objects, we see them as they were, not as they are that instant. By the time we see light from a far away object, it's already outdated information. When you look at our moon, you are seeing it as it was over a second ago. When you look at the Sun (don't stare directly into it) you are seeing it as it was about eight minutes ago. When you look at distant stars, you are not seeing them as they are now but how they were years ago. Some of them may have already exploded but we wouldn't know it until the light from those far away events reaches our eyes.

Roemer and others calculated distance and orbit information and figured that light was traveling somewhere in the neighborhood of 150,000 miles per second. A few other scientists later perfected this calculation, and the more accurate velocity of light was determined to be 186,000 miles per second. Pretty neat huh? And what does this have to do with relativity? We'll find out.

Okay, now that we've covered that, lets fast-forward all the way to 1865. There is this Scottish physicist named James Clerk Maxwell and he is doing a lot of work in the field of electricity and magnetism. One of the things that Maxwell discovers is that, in addition to the fact that a changing magnetic field can induce an electric field, a changing electric field can induce a magnetic field. Well, what the heck does that mean? Okay – Let's start with a magnetic field. If you have a magnet, you already know the magnet will attract and "stick to" iron objects. There is a magnetic field around the magnet, which serves as a kind of invisible "tangled web" that iron objects can get caught in, just like ordinary objects can get caught in a gravitational field. Lesser known to non-scientists is what's called an electric field. An electric field is a field surrounding charged objects. Electrons have electric fields around them. Protons have electric fields around them. Charged atomic or molecular fragments called ions have electric fields around them too.

Before Maxwell hit his peak of discovery, it was already known that there was some relationship between electricity and magnetism. Faraday demonstrated that electric current running through a wire actually produces a magnetic field around the wire. It was also known that under proper conditions a wire moving through a magnetic field would start to generate an electric current.

Among other things, what Maxwell determined was that when a changing magnetic field generated an electric field, the electric field could then change and then generate another changing magnetic field. That would then generate another electric field which would generate another magnetic field and continue to self perpetuate in an outward wave of alternating electric and magnetic fields. This is what is known as electromagnetic radiation or "electromagnetic waves." Maxwell was able to brilliantly calculate the velocity at which these waves were able to travel across space by mathematically calculating the rate at which the alternating electric and magnetic fields continually generate each other. When Maxwell ran the numbers through the formula, he calculated a velocity of approximately 186,000 miles per second. Knowing what the speed of light had already been reported to be, Maxwell quickly and correctly deduced that light itself must be a visible form of an electromagnetic wave!

What followed for about forty years was conjecture on what exactly the waves were and how they traveled through space. A consensus started building that the light waves needed a medium to travel through. Sound waves have air to travel through. With no air, there is nothing to transmit the sound vibration that was created. If a tree falls in a forest with no air, it will not make a sound. Water waves have (you guessed it) water to travel through. Drop a stone in a pond and waves will ripple in all directions. Drop a stone in an empty swimming pool and look, no waves. So, it was thought that light must travel through an invisible medium that scientists referred to as "ether."

In 1886 Albert Michelson and Edward Morley constructed a device that they hoped would detect this "ether" wind. It worked by sending light waves in multiple directions and was capable of measuring a time difference for each direction. To use a more understandable example, let's say you had a tractor hauling a double trailer down the highway at a speed of about 65 mph. And let's say there were two air horns right between the two trailers – one facing the front and one facing the rear. Now imagine a couple of thrill-seekers holding on to the outsides of the trailers as they are barreling down the road. Thrill-seeker Fred is at the front of the front trailer and thrill-seeker Richard is at the rear of the rear trailer. If the two air horns (which are at the exact midpoint between the two thrill-seekers) go off simultaneously, the sound traveling through the air will reach Richard before the sound reaches Fred, since Richard is moving through the air *toward* the sound and Fred is moving *away* from the sound.

So the Michelson-Morley device was set up using the Earth as a giant tractor trailer hurling through space in a certain direction to see if the back of the device would see the light before the front of the device as the light was presumably traveling through its universal ether. However, when the results came in, they showed the travel times for each direction to be equal. This was a confusing result. If you don't understand this result, don't worry. This left the top physicists of the day scrambling for answers too. It would seem that a lot of mysterious pieces would need to fit together in order to make sense of Galileo's Relativity, light waves, and the results of the Michelson-Morley experiment. And, although several scientists have theorized as to how all of these concepts fit together, the theory that was eventually adopted by the scientific community was the one published in 1905 by Albert Einstein.

To give you a background on who Einstein was and what he accomplished as a scientist would be such an extensive dialogue, that it would take hours. In 1921, he won the Nobel Prize for the Photoelectric Effect, which was a discovery that explained how, under proper conditions, light could strike a metal surface and produce an electric current in the metal. He was also famous for developing a certain math equation. If I remember correctly it's $E = mc^2$. I'm sure you have all heard of it. It demonstrates the fact that a small amount of mass has the potential to be converted into an enormous amount of energy. It is the foundation upon how a nuclear power plant produces its energy. And how about a Laser beam? The "S" and the "E" in LASER stand for Stimulated Emission. If you are wondering what scientist was the first to theorize on the stimulated emission of light from atoms way back in 1916, stop wondering; it was Einstein.

Einstein was famous for devoting a lot of thought to many issues that perplexed physicists. As I mentioned, the successful contributions that he was able to make were mind-bogglingly numerous. And no problem was too big or too small. He could theorize about gravity in the universe or the random motion of molecules. One wonders if Einstein's burning curiosities had been in the field of medicine rather than physics, what contributions he could have made to medicine a hundred years ago that we are still missing today.

Well anyway, I guess that brings us to the specific contribution that we are here to discuss today: Einstein's Special Theory of Relativity. As with Einstein's other projects, he developed Special Relativity only after a considerable amount of thought. Einstein would spend hours wondering how everything scientists had been learning about light could be incorporated into Galileo's Relativity. One of the things that bothered Einstein the most could be summed up with the following scenario:

You are in a spacecraft traveling close to the speed of light and a light signal is generated from the back of the craft. If it takes longer for the light to catch up to you and then pass you by at a slower speed, then you would know you were in motion and that would violate Galileo's Relativity. With this in mind, Einstein concluded that the speed of light must remain constant, regardless if the light source and/or the observer is moving. Otherwise the observer *would be able to tell that they were moving*.

So, Einstein's two main postulates of Special Relativity are that:

1) Galileo's Principle of relativity is to be preserved. That is - all motion at constant velocity is to be considered relative, and the laws of physics for moving frames of reference are the same as the laws of physics that apply to stationary frames.

And

2) The velocity of light is to be considered constant, regardless of the state of motion of the light source.

What this means in English is that Galileo's original Principle of Relativity remains preserved for free-float reference frames and the velocity of light must be considered to be a universal constant. According to Einstein, if you were in a moving vehicle and you turned on your flashlight with a mirror and a stopwatch and bounced light beams off the ceiling, as long as the windows were covered, everything would still seem as if you were not moving. Now if you think about it for a minute, the second postulate nicely reinforces the first one. It's kind of like bringing Galileo's 17^{th} century relativity into the 20^{th} century by addressing the issue of light waves and incorporating them into the existing theory. So, as crazy as it sounds, Einstein brought a fresh upgrade to relativity by declaring the speed of light to be a necessary universal constant.

If Einstein stopped there, he knew he would have a problem. Just exactly how could the speed of light be a constant for all observers? A thought experiment that conveys what exactly Einstein was anguishing over goes a little something like this:

Imagine that there is a train that can travel down a track at 90% the speed of light. And imagine one of the train cars has windows made of the type of glass that is a mirror on one side and see-through on the other. The passenger on the inside of the train car can't see outside because the windows are all mirrored, but a person outside, standing near the track will be able to see inside the train car through the glass as it is going by. Now if both postulates are correct, then a person on the inside of the train with a couple of flashlights can shine light beams in every direction and the speed of light will come out to be the same for all of the beams from the perspective of the passenger. Otherwise he would be able to tell that he is moving. And as I mentioned earlier, that would be a violation of Galileo's relativity, which is Einstein's first postulate. And the person on the outside, looking in as the train car is whizzing by, would also have to see the light traveling 186,000 miles per second, because that is Einstein's second postulate. But if you think about it, the sideline observer should see the effect of the velocity of the light beam being added to the velocity of the train, and the beam would appear to be pushed along the track at a faster than 186,000 miles per second velocity to him.

This is precisely what Einstein was toiling over before he published his 1905 paper. He knew he had to resolve this issue before he could publish a complete solution. He continued to think about this until one day he had a Eureka moment. The next day he met with his longtime friend Michael Besso and told him that he had solved the problem. As hard as the solution was to believe – it was the only thing that made sense to Einstein. It was the only thing that allowed both postulates to work.

What Einstein proposed was that the rate at which time itself elapses is relative! He wasn't the first scientist to wonder about this possibility but he appeared to be the first to unify this concept with motion and light wave behavior. Now, I suppose that what most people assume is that the Universe (whatever that is) has time tick by with some sort of universal clock. For example, even though California is three hours behind New York, it is because of the position of each location with respect to the Sun at any given time. If we chose to, we could have done something less convenient and synced up all of the clocks on the planet for the same time. That would mean that when it was 8:00 pm on the east coast it would also be 8:00 pm on the west coast (to think of all the Monday Night Football games I would have been awake to see the endings for…) and 8:00 pm on the rest of the planet as well.

The point is that even though clocks are set at different times, they run at the same rate everywhere. California is always exactly three hours behind New York because the clocks tick at the same rate. Now, I'm sure that most people just assume that the rest of the universe is on the same clock-ticking schedule too. Well, this is the very assumption that Einstein said couldn't be true. Because, if all motion that is constant velocity, is relative (and could legitimately be considered stationary depending on the frame of reference) and if all light wave motion has one single possible velocity for all observers, whether they are moving or not – then the rate at which time passes must be variable for different observers so that the speed of light comes out exactly the same for all of these observers.

Is this too complicated for us to understand? No, definitely not. What is velocity? From a mathematical point of view, it is the distance covered divided by the amount of time that it takes to travel that distance. So, if I drive a constant velocity down the highway and my speedometer is broken, but I find that I traveled 120 miles in two hours, then I could take my distance of 120 miles and divide it by my time of two hours and get:

$v = d/t \qquad v = 120 \text{ miles}/2 \text{ hours} = 60 \text{ miles/hr.}$

Now, in order for the speed of light to come out to be exactly the same for all observers, watch what needs to happen: Using the two observers from earlier (one inside the moving train, one on the ground watching it go by) they would each see the light beams inside the train covering different distances. Remember, the person inside the train is seeing the beams bounce around from a perspective of being in a stationary, free-float frame location since he is moving in unison with train. The person outside the train is seeing the beams bounce around as moving beams along with the added velocity of the train's motion. So for the very same event, each observer is seeing the very same light beams cover different distances!

If we go back to our equation: v = d/t (Einstein used a more complicated equation but this will be sufficient for our point) we can see that for each observer, the velocity (v) must be exactly 186,000 miles/sec. And since the distance that the light beams traveled is different for each observer, then the time (t) must be different for each observer too, so that when (d) is divided by (t) for each person, the (v) value will come out to be 186,000 miles/sec for each observer. When Einstein did the math he found that without the time adjustment, the light beams would appear to cover a longer distance for the observer on the sideline than they would for the person inside the train. Therefore more time would tick off the clock for the sideline observer than the amount of ticks for the traveler on the train.

What this means is that relative to the sideline observer's clock, the traveler's clock would be running slower. If the sideline observer watched sixty seconds tick off of his wristwatch, he would have to accept the fact that during that very time frame, only forty or fifty seconds would tick off of the traveler's watch. This is because time itself has slowed down for the moving train. This isn't anything you would detect with a train traveling 70 mph, but near the speed of light, the clock rate differences would surely be noticed.

Now Einstein had everything he needed to publish his theory. And in June of 1905, that's exactly what he did. The paper that introduced his Special Theory of Relativity appeared in a journal called *Annalen der Physik* (which means *Annals of Physics* in German) and the paper was titled: *On the Electrodynamics of Moving Bodies.*

His first postulate states that the Principle of Relativity continues to hold true. Einstein states in this paper "the phenomena of electrodynamics and mechanics possess no properties corresponding to the idea of absolute rest." As far as Einstein was concerned, an idea that started with Galileo in the 1600's had held up and would be an integral part of his overall theory. A vehicle traveling at a constant velocity of 60 mph would seem to be at rest if you were on the inside with no view to the outside. From the point of view of a stationary outside observer however, the vehicle is traveling at 60 mph. Relativity says that both are correct. If the vehicle comes to a stop on Earth and the traveler gets out and sits on a lawn chair and is now no longer in motion – he is at rest relative to the Earth, but relative to the Sun - the man, the lawn chair and the entire planet Earth are flying through space with a pretty impressive velocity.

Okay, so then, the Sun is the thing that is at rest, right? Well, that's not the case either. The Sun is just one of many stars that is also rotating in the Milky Way Galaxy. And the Milky Way Galaxy is in motion with respect to the other galaxies in the Universe. So it appears, according to the principle that (unless of course, you are accelerating) there is no absolute motion or absolute rest. Two ships could be in the far reaches of outer space. One could be moving by the other at constant velocity and it would not only be impossible for either to tell which was moving, it wouldn't even make sense to attempt to determine. There wouldn't be anything to determine. All you could say was that relative to each other, they are in motion. At that point, they would each be their own independent free-float reference frames. Ship A would see B as moving and Ship B would see A as moving. According to the postulate, both could be viewed as correct.

The same holds for a ship flying by the Earth. If aliens from another planet, cruise by Earth at a constant velocity, are they considered in absolute motion while Earth is in a state of absolute rest? According to the postulate – no. The earth is moving relative to the Sun and the Sun is moving relative to other stars in the galaxy, and the galaxy is moving relative to the other galaxies. So, both the alien spaceship and the earth are in motion, and if you say that one is in motion and the other is not, it would only be relative to what you are comparing it to.

This means that there is no preferred frame of reference in the universe. You can't go to an exact center of the universe and find a stationary clock tower that is the reference for all other universal motion. There is no such thing. The best one could do is to say that the universe is a zoo of objects that are all in motion, or at rest, relative to each other.

Okay, let's move on. The second postulate in the 1905 paper reads: "Light is always propagated in empty space with a definite velocity (represented by the letter *c*) which is independent of the state of motion of the emitting body." This is significant because it contradicts the understanding of motion previous to 1905. If I am at the rear of a train car and throw a baseball to the front of the train car with a velocity of 30 mph, I see the ball go forward at 30 mph. If the train is traveling 70 mph while I throw that same ball, then an observer on the ground looking through the windows will see the ball propel forward: 70 + 30 for a total of 100 mph. The Theory of Relativity says that light doesn't work that way. Light will always come out to be the same velocity whether it is shining from a stationary lighthouse or a moving train. Einstein goes on to state that the "ether" everyone has been conjecturing about isn't necessary and may not exist at all in accordance with there not being an "absolute stationary space."

The other main point of Einstein's Relativity – replacing the concept of absolute time with clock rates being dependent on velocity, is described in the 1905 paper as follows:

If there are two stationary clocks at point A and point B and the clocks are synchronized, and the clock at point A moves to the clock at point B at a velocity v, upon its arrival at point B, the clocks will no longer be in sync. The clock in motion (A) will be lagging behind the stationary clock (B).

This is because while Clock (A) was in motion, time was elapsing more slowly than time was for the stationary clock (B). So, while clock B was sitting there minding its own business, ticking away 45 seconds or so, during that same time, the moving clock A was ticking off only 30 seconds because it was running slower. This means that if the clocks were both synchronized in the beginning, the moving clock would be fifteen seconds behind when it reached the other clock. By the way, these time discrepancies are arbitrary. According to the theory, the faster the velocity of the moving clock, the slower it will run. So if clock A is moving at 99.99% the speed of light, it will have a much larger lag discrepancy than if it were only traveling at 5% the speed of light.

A point to be clear on is that Einstein is not simply saying that high velocity has some sort of detrimental effect on a clock's accuracy as if to create some sort of defect. There is nothing wrong with the clock. It is accurately displaying that *time itself* is slowing down for a moving object.

At this point it is very important to understand that the concept of relative time rate was introduced by Einstein to reconcile the first two postulates. Einstein suggested this necessity, because without it, some observers would see light signals propagate at speeds other than c. Years later at a talk given in 1922, Einstein recounted how he shared the good news of solving the relativity problem with Besso, before he completed the 1905 paper:

"Thank you (Michael). I have completely solved the problem. My solution was really for the very concept of time, that is, that time is not absolutely defined but there is an inseparable connection between time and the signal velocity."

It is important to recognize that Einstein used increased velocity on an object as the reason for how or why a clock runs slower. I can't stress enough how important it is to understand the original reason for the assertions in the 1905 paper. Two other things to keep in mind are that: 1) Einstein had Clock A *arrive* where clock B was, to make the comparison and 2) Einstein stated that clock A would be lagging behind B but not the other way around. Very important!

With this paper, Einstein seemed to have nicely tied together some concepts that were nagging physicists, and at the same time presented a theory that seemed to fit with the experimental results of the Michelson-Morley experiment. So what's the problem?

Well, there is a big one. It turns out that by using these three main points to explain light, motion and time; Einstein created quite a conundrum for himself. If we look at the first postulate, which is a defense of Galileo's Principle of Relativity, Einstein says that all constant velocity is relative. There is no state of absolute rest. There is no preferred frame of reference. In fact, Einstein continued to state decades afterward that "The laws of physics in a moving frame are the same for a frame that is taken to be stationary." Every planet, every ship moving at constant velocity, every *anything* moving around the universe at constant velocity is its own independent free-float reference frame. The only way you could report that any free-float frame is in motion is to have another object to reference it to. Einstein was very clear about this matter.

So then, how do you suppose that we could explain why moving clock A experiences a time slowdown while clock B continues at its original rate? Clock A is moving toward clock B at velocity v, and when it arrives at clock B, according to Einstein, we would notice that clock A would be running behind clock B. Now we need to remember the reason Einstein said it was essential to insert relative time into Special Relativity in the first place. The moving clock would see the same light signals travel a different distance, and to compensate so that the speed would still come out to be c, the moving clock would have to run slower.

Well, couldn't we say that B could claim it was in motion relative to A, and any light signals originating from A would need to be compensated for by the B clock running slower? According to the first postulate – you bet we could.

We would have to admit that B is not in an absolute state of rest, nor is A in an absolute state of motion. They are on equal footing as they perceive each other as motoring past at constant velocity. So when A arrives at B (as stated in the 1905 paper) why is clock A running slower?

And so the concept of the Twin Paradox was born. And although the Twin Paradox is a topic that hasn't permeated many cocktail parties throughout the past hundred years, among pockets of science enthusiasts, it's something that has never really gone away.

The point is that if time is slowing down for clock A while the rate at which clock B runs doesn't change (so that when A arrives at B they are no longer in sync) there clearly must be something happening to A during the journey that B is not experiencing, right?

Well, that seems innocent enough on the surface, but that would appear to put Galileo's principle in jeopardy. Something has clearly happened to clock A on a physical level that was not experienced by clock B. Wouldn't this make one clock in a preferred state of motion over the other?

If Special Theory of Relativity of 1905 is a correct theory, then why would we have such a glaring conundrum already? Is it possible that Galileo's principle can remain completely preserved, and at the same time, have clocks slow down for the specific reason that Einstein said they would? The case that we are presenting here today will show that it is not likely. Now, if Special Relativity is that uncertain, how is it that it is still accepted by physicists today? Have the physicists not heard the criticisms? If relativity is still accepted, those criticisms must have been long since addressed and all concerns alleviated, right? Maybe there needed to be a slight revision? Maybe Einstein meant to add something in the 1905 paper and when he accidentally left something out, there was a big misunderstanding, and when Einstein promptly cleared this up, there surfaced the "Complete" Special Theory of Relativity which not 50%, not 75%, but 100% of the physics community understood clearly and immediately embraced decades ago. This has got to be what happened right?

If this is what happened, it would explain why critics of Special Relativity are referred to as cranks, crackpots, and conspiracy theorists. In fact, there was even a well-known physicist who was recently quoted as saying, "Several of us have speculated that there must be a particular psychosis that results in people believing that they have disproved relativity."

While I'm grateful to the physics community for opening the door, in the event we wish to change our plea to insanity, I assure you that my client is quite sane.

But is this what really happened? Has relativity been airtight for decades and these crackpots just didn't get the memo? Or, maybe they got the memo and it was too complicated for them to understand, so as expected of any underachieving-genius-wannabees, they criticized it. Or, maybe deep down inside they have known all along that everything about relativity could be true but since it poses such a threat to their belief system of how they would like the universe work, they lash out with the hope of restoring our traditional concepts of space, time and motion?

Well, fortunately for my client, but sadly for the scientific community, this is not what has happened. In fact, the events over the past hundred years or so, I'm afraid, do not paint a very favorable picture for the opposition.

We will demonstrate that by the time 1918 rolled around, there was growing concern about relativity. Even though many within the physics community were accepting relativity, there were still a significant number of critics that pointed to the twin paradox as a perfect exploitation of the theory's inconsistencies.

Einstein himself was aware of this and during that year he published an article that appeared in *Die Naturwissenschaften* (which is a lot tougher to say than *Annalen der Physik*) that addressed the concern surrounding the twin paradox. Recall that the paradox exploits that A should see B run slower and B should see A run slower for the explicit purpose of time ticking at a different rate to nicely reconcile the speed of light to its universal velocity. But recall Einstein gave preferential treatment to A since it was in "motion" and when A reached B, it had the clock that was running behind.

In the 1918 article, Einstein's solution to the paradox is none other than – Acceleration! Yes, that's right. Clock A experiences an acceleration that B does not. Okay – so what? Where did that come from and what does that have to do with his original theory of relativity?

It turns out that after 1905, Einstein published other papers on what was referred to as the General Theory of Relativity. From a period of 1907 to 1918, Einstein assembled quite an extensive theory on how gravity fits into the universe with respect to space, time, motion and light. It began in 1907 with what Einstein described as: "The happiest thought of my life."

This thought was a recognition that if someone were falling freely in a gravitational field, they would not feel their own weight. Now, I realize that this is a small consolation for someone who is about to abruptly impact the ground, but it did lead Einstein to some pretty astute conclusions. Imagine an elevator on the top floor of a 70-story building where the cable and safety cables have unfortunately become severed. During the time that the elevator and its passengers are in a state of free fall, they would feel weightless inside of the elevator. Someone could take a pen or set of keys out of their pocket and let go of them and they would appear to float in front of the passengers. This is because everything in the elevator is free falling to the ground at the same rate. So, for that brief moment, everyone would experience a state of weightlessness. Einstein recognized that the sensation the passengers experience during freefall would be identical to the one experienced if the elevator car were transported to outer space and the elevator and its contents could all float freely, away from any gravitational influence.

Einstein also recognized that the opposite effect would be true. If the top of an elevator floating in outer space was suddenly tethered to a space ship and accelerated through space, the passengers would feel the floor of the elevator exerting pressure on their feet. They would be continuously pulled upward and feel a sensation of simulated gravity. As long as the elevator continued to accelerate, the sensation would be indistinguishable from being in a gravitational field. This time, if someone were to let go of a pen or a set of keys, the objects would appear to "fall" to the floor of the elevator, even though it was really the floor of the elevator that was moving upward to meet the objects. Einstein concluded that being in a moving frame of reference that is experiencing acceleration is equivalent to being stationary in a gravitational field. This was the beginning of *The Principle of Equivalence.*

Einstein also looked at how light signals would propagate back and forth between various points in an accelerating frame and in a gravitational frame. He concluded (for different reasons, along with different equations than discussed in special relativity) that time itself would experience a slowdown while in a lower position of an accelerating system and therefore, due to the principle of equivalence, would also slow down in a gravitational field. Specifically, the closer you are to the source of a gravitational field, the slower your clock will run. A clock resting on the ground will run slower than a clock on the top of the Eiffel Tower. Not much slower mind you, but slower. And a clock on the ground (lower clock) will run noticeably slower than a (higher) clock at a significant distance from the surface of the Earth and its gravity. I will often refer to time slowing due to acceleration or gravity as the *general relativity* effect on clocks. I will revisit some of the finer details of this portion of the paradox later, but for now I will say that in 1918, Einstein argued that upon completion of clock A's journey, it was lagging behind clock B because it experienced a real acceleration that simulated a gravitational field - with A and B being in different relative positions with respect to that field.

So let's review what we have so far: In 1905 Albert Einstein stated that Galileo's Relativity principle will hold true and no object in the universe could be considered in a state of absolute rest or in a preferred state of motion. He then stated that the speed of light is to be considered absolute, regardless of the velocity of its source. He further stated that time itself will slow down for a moving frame so that the speed of light remains constant for all observers. Einstein provided no mechanism for the time dilation, nor did he suggest a cause and effect relationship between A "seeing" light signals at B and its time slowing down, only suggesting that the former condition made the latter necessary.

This incredible prediction of time being relative to its state of motion was originally justified with a very specific explanation as to why. Hopefully by now, you have recognized that this original 1905 explanation took place two years before Einstein began his theories of gravity and General Relativity. Then years later, after there is obvious questioning in the form of the twin paradox, Einstein clears up the "confusion" about the paradox by introducing an additional time dilation effect created by Acceleration – an explanation that hadn't even been dreamed of until at least two years after the original 1905 paper!

Is everyone still with me? To add to the confusion, Einstein published additional relativity papers in 1911 and 1916 that appeared in Analen Der Physik. The 1911 paper discussed the details of the equivalence principle, including light signals and clock rates in an accelerating field, but curiously, does not discuss this effect as a necessary part of a clock discrepancy for a traveler on a high speed journey. In the 1916 paper titled: *The Foundation of the Theory of General Relativity*, Einstein discussed some incredible predictions about how gravity affects light, space and time, including the prediction that a beam of light would actually bend in a gravitational field. He also devoted a section of the 1916 paper to the Special Theory of Relativity. Even though this was eleven years after the 1905 paper, once again, he didn't attempt to clarify the combined effect of special and general relativity on time dilation in this section.

Even more curious are Einstein's writings after the 1918 twin paradox paper. In particular – Twenty years after the 1918 paper, Einstein and Leopold Infeld wrote a 297 page book, *The Evolution of Physics* in which they devote enormous sections to both the explanations of special relativity and general relativity, but oddly, do not discuss the paradox, nor do they confirm anywhere that the accelerating clock is partly responsible for the final clock discrepancy when two clocks unite.

In addition, there were several editions of Einstein's book: *Relativity - the Special and General Theory*. Even as late as 1952 (Einstein died in 1955) Einstein chose to describe the "clock slowing with velocity" portion of Special Relativity, by comparing a moving clock with a stationary clock without the clocks uniting to compare clock times. This is curiously short of what was confidently stated in the 1905 paper.

An additional publication worth mentioning is the fifth edition of *The Meaning of Relativity*. This edition, published the year after he died, had revisions that he submitted as late as 1954. This is a highly technical and mathematical description of both special and general relativity. Definitely more complex than what is found in the less technical *Evolution of Physics*. If Einstein felt that the twin paradox concept was too technical of a topic to discuss in his other publications, he certainly had a chance to present it in this book. So, what did Einstein say about relative time in this book? Not much. In the *Moving Measuring Rods and Clocks* paragraph found in the chapter on Special Relativity, he compares a moving clock with a stationary clock by stating (with my comments added in parenthesis):

A clock at rest at the origin, $x_1 = 0$ *of (reference frame) K, whose beats are characterized by l = n (l equaling "light time" which is what Einstein uses as the time variable here) will, when observed from K ' (reference frame in motion with respect to K) have beats characterized by l ' =* $n / \sqrt{1-v^2}$ *and shows that the clock goes slower than if it were at rest relatively to K '.*

And with regard to general relativity's effect on time, Einstein limits his comments to:

The rate of a clock is accordingly slower the greater is the mass of the ponderable matter in its neighborhood.

So, you may wonder why Albert Einstein, after developing one of the most incredible theories in 1905, which included a universe-shattering revelation that time itself is relative, and after fine-tuning his detailed description thirteen years later, had been so reluctant to discuss his iron-clad theory that explained why a traveler's clock would be running behind an Earthbound clock after returning from a high speed journey. If Einstein had a lot of confidence in his 1918 update to the special theory of relativity, he sure had a funny way of showing it didn't he?

And what has been the position of the physics community in the past hundred years? The answer to that question doesn't exactly clear up the "confusion" either. In the 1962 edition of his book *Einstein's Theory of Relativity,* world-renowned physicist Max Born, explains the twin clock paradox by endorsing the Einstein 1918 version. He demonstrates mathematically how, during the constant velocity portion of the journey, clock A will see B run slower, while at the same time B will see A run slower. (This will be explained in detail later.) He shows how this is compensated for during the acceleration/deceleration phases for the traveling clock – so that when they reunite, the clock that journeyed will be running behind the clock that remained stationary. He concludes by saying that "the clock paradox is due to a false application of the special theory of relativity, namely, to a case in which *the methods of the general theory should be applied.*"

Is this the opinion of all physicists? Well, let's continue. In the 1999 edition of their 300 page relativity book, *Spacetime Physics*, John Archibald Wheeler and Edwin F. Taylor, address the twin paradox by asking the question: *Do we need general relativity?* And they quickly answer, *No*. They further sum up the paradox by saying: "there is never any contradiction between a single clock in one frame and a single clock in any other frame. In this case special relativity can do the job just fine." Wheeler should know, right? He coauthored a textbook on gravitation and if I'm not mistaken, was the one who coined the phrase "black hole." So if there were anyone who was considered an expert in the areas of special relativity and general relativity, it would be Wheeler.

Next we have Dartmouth College Professor Ronald C. Lasky. Professor Lasky describes his take on the twin paradox in a 2003 *Scientific American* article this way:

When the paradox is addressed, it is usually done so only briefly, by saying that the one who feels the acceleration is the one who is younger at the end of the trip. While the result is correct, the explanation is misleading. Because of these types of incomplete explanations, to many partially informed people, the accelerations appear to be the issue. Therefore it is believed that the general theory of relativity is required to explain the paradox. Of course, this conclusion is based on yet another mistake, since we don't need general relativity to handle the accelerations. The paradox can be unraveled by special relativity alone, and the accelerations incurred by the traveler are incidental.

Lasky uses the concept of length contraction to justify the traveler's clock lagging behind upon returning. As you can see, he makes it very clear that gravity and acceleration described in general relativity have no business in the explanation of clock discrepancies.

In recent years, however, Einstein's 1918 version, endorsed by Max Born, has been making a comeback. In his 2005 book, *It's About Time*, physicist N. David Mermin discusses general relativity as a solution to the paradox. Additionally, O. G. Gron, from the Institute of Physics at the University of Oslo, provides a very lengthy mathematical argument for why the general relativity portion of the journey is essential for resolving the paradox. This argument is presented in the February 2007 edition of *Current Science* as a critical response to a December 2005 paper published in the same journal by C. S. Unnikrishnan. In his paper, Unnikrishnan provides an in-depth look at relativity, including a thorough discussion of the differences between the Einstein of 1905 and the Einstein of 1918. Unnikrishnan provides an argument for why he thinks the Einstein 1918 version does not work and it is this point that Gron challenges in his response.

Even more recently, in the *American Journal of Physics*, Physicist Dan Styer devotes a special section of his September 2007 paper to the twin paradox. Although his mathematical approach is different, he arrives at the same conclusion as Born, Mermin and Gron: The General Relativity/acceleration phase of the traveler is the necessary key to providing the solution to the paradox.

And if you're wondering what physics students have been taught during the past thirty years or so, we have submitted a stack of college physics textbooks as evidence which, upon review, will clearly show that there is no consensus there either.

So apparently, what we have, unless my client and I have missed something, is a decades-old theory called relativity, developed by Albert Einstein, which to this day has no working explanation that all scientists can agree on. Now, I wonder what psychosis the pro-general relativists think the non-general relativists are suffering from? And do the scientists that don't deem general relativity necessary, think the pro-general relativists are paranoid? Delusional? Overachievers? Too detail oriented? And they want to stop my client from teaching physics?

Okay, so how could this have happened? My honest answer is that I'm not quite sure. I do have a timeline theory that I will share with you that may shed some light on this whole mess, but it is just a theory.

One of the first things that happened with special relativity was that Max Planck gave it his seal of approval. Max Planck was one the most accomplished and respected physicists of his time and there is no doubt that this had influence and generated additional exposure for the special theory of relativity.

I think the second thing that happened was that Einstein was becoming increasingly recognized for predictions outside of special relativity that were discovered to be true. Remember that in 1921, he won the Nobel Prize for the photoelectric effect, which had nothing to do with relativity. He was also recognized and appreciated for his earlier work on his Brownian motion theory (which involves molecular motion) and later, his specific work in general relativity. He definitely hit a notoriety peak when his prediction that gravity could bend light, was experimentally verified in the 1920's. It wasn't long before Einstein became a household word. I think that to this day, the knowledge of Einstein's incredible accomplishments bear some influence on how easily one accepts special relativity.

And now, moving on to the physical evidence. It has been observed experimentally that fast-moving objects really do age more slowly. Rapidly moving sub-atomic particles age more slowly than those moving slower and even ultra-accurate atomic clocks on moving airplanes tick more slowly than stationary clocks do. And that's not all. It turns out that clocks that are closer to a gravitational source (lower clocks) tick more slowly than clocks farther away (higher clocks) do.

So wait a minute? The two circumstances in which Einstein predicted that time will slow down (increased velocity and gravitational field) turned out to be correct? The answer is Yes!

Well, what's the problem then? Why don't we just pack up and go home right now? Einstein was correct and these psychotic nuts are wrong, right?

No, that's not the argument that we are making here today. Most critics of relativity, including my client, do not contest the scientific evidence that reveals the relative nature of time. Most critics have an issue with the theory's explanation of *why* the evidence is so. There is no proof that it is consistent and cannot possibly be true in its entirety. And because of that, many over the years have not had an issue with the relative nature of time, but rather with Einstein's theory as to why it is relative. But I have to admit, with all of the endorsement that Einstein has received, along with the accolades he received regarding other theories and predictions, and add to that the fact that time really does slow down in the cases where Einstein predicted, it's no wonder that we are where we are today. Now, before I continue, I have to say that you will see us be very critical of certain aspects of the theory throughout this trial, including aspects found in a number of books and articles from various physicists. Please do not view any of this as a personal attack on these scientists. For the most part, we are talking about a group of very accomplished scientists who are extremely intelligent and have made wonderful scientific contributions outside of the field of relativity. I think what has happened is that, for years, they have been scrambling to show how certain assumptions fit in with the physical evidence that does exist. For the most part, I think they believe these assumptions to be true. We will show however, that that is not possible.

So what can we make of all of the various explanations for relativity? Well, the first thing we can say is that they can't all be true. It's not possible. If the length contraction hypothesis was true and the general relativity explanation was also true, then there would be a double compensation and the calculated prediction would not jive with experimental evidence. In other words, if my pants were too tight for me (which happens after every Thanksgiving) then I could either lose weight or buy larger pants, but if I did both, then the pants would be too loose. It would be an over-adjustment. Relativity has the same problem. Some Scientists argue that the length contraction hypothesis claims to make a perfect adjustment and others claim that the general relativity hypothesis makes a perfect adjustment using an entirely different method. If both were true, there would be an over-adjustment and the calculated result would not reflect what is observed by experiment. Too add to the fun, some scientists argue that both length contraction and general relativity are employed at different parts of the journey and produce a final result from a combination of both effects. We will show that all of these theories have serious problems.

The first thing we want to keep in mind is the fundamental explanation for why Einstein says time has to slow down for the object in motion, which is: so that the speed of light remains constant for all observers.

So let's return to the two ships passing in the night. Ship A whizzes by ship B and as it does, B looks at the light bouncing around inside of ship A. At this point, A's time has to slow down, because if it didn't, B would see light going faster than light speed since it would add A's light to its ship velocity. Now, according to Galileo, B can claim A is moving, and A can claim B is moving, so A would have to see the same time slowdown in B that B would see in A since the light signals are synonymous with the rate at which time flows. And not just see time slow down. Time itself would actually be running slower for A from B's perspective while at the very same time, time would be running slower for B from A's perspective. This is the crux of Einstein's relativity. It's one of the things that set it apart from Galileo's relativity. The rates at which time elapses are interdependent on what the light signals are doing based on each ship's relative velocity. Remember, Einstein himself never established what the cause and effect relationship was between motion and clock rates but did suggest that it was an inseparable package deal. Increase the relative velocity of an object - and changing clock rates will be observed.

Now, if I have two clocks, I could accept the fact that one is running slower compared to the other, but how could both be running slower from each other's perspective at the same time? What kind of universe are we running here? This was the conundrum that sparked the paradox to begin with. Especially since it was stated (and discovered later by observation) that the clock that journeyed would in fact be running slower when the clocks later unite to compare times. And, as you can see, there have been a variety of attempts to resolve this issue with a very diverse set of explanations.

To get into that, let's first take a closer look at the general relativity explanation to the paradox. According to the principle, clocks A and B will be running more slowly to each other at the same time, but when the trip is over, A will be running definitively behind B. Einstein's solution to this conundrum was that the acceleration that is experienced by A will exactly compensate for the dual slowdown experienced during the constant velocity portion of the trip. Einstein says that the light signals coming from the stationary clock B would become that of a "higher clock" and the traveling clock A would become the "lower clock." as observed in the Equivalence Principle from 1911. This is the point mentioned earlier about a clock on the surface of the Earth running slower than a clock at the top of the Eiffel Tower. This allows stationary clock B to catch up to and then surpass the clock time on A's clock.

It turns out that this is a great way to preserve the Special Theory of Relativity. You see, it turns out that if the theory isn't presented in this manner, then there is preferential motion after all, and Galileo's boat is sunk, taking down with it, Einstein's first postulate. It's the only way to explain the clock A slowdown without giving it preferential motion. It also appears to accomplish this while preserving the direct connection between light signal propagation and clock rate. No other relativity explanation accomplishes both of these points.

So the relativity of 1905 said that clock A slowed down on its journey to B because of velocity. And the conundrum lies in trying to explain how velocity can be responsible for slowing one clock but not the other without considering A or B in absolute rest or absolute motion. And equally important, without breaking the inseparable connection between how light signals are *received* and the rate at which time ticks.

The 1918 solution, which proposes that the clocks do in fact slow down for each other at the same time, works as follows:

During constant velocity, from B's perspective, A's clock is running slower than B's. And from A's perspective, B's clock is running slower than A's. This sounds like madness but we can't throw out an idea just because it doesn't make sense to us. There are a lot of things in science that don't make sense but are backed up by experimental evidence. We can't discard this crazy dual time slowdown because we can't imagine how it could possibly happen. In any event, to resolve the times during the rest of the journey, it is proposed that, as moving clock A begins to decelerate, turn around, then accelerate back toward B, the A clock is slowing the rate at which it is moving away from B and after the turnaround, it is accelerating toward B. These are the time periods where A sees Stationary B run *not slower, but faster* due to the higher clock/lower clock explanation.

A potential problem with that theory is that the two clocks are not in the same situation that the equivalence principle of 1911 used. The 1911 paper used two clocks that accelerated in a particular direction while the clocks maintained a fixed distance from one another. This would create an asymmetrical situation regarding light signals communicated between the clocks (which focus on frequency rather than velocity). Imagine again an elevator in outer space connected to a rocket ship by a cable. The ship is continuously tugging on the elevator, therefore creating acceleration. As it is moving in what would feel like an upward direction for someone on the elevator, two clocks (one on the ceiling, one on the floor) begin to trade light signals. The signals sent by the lower clock would move to the higher clock as the higher clock is accelerating *away* from the signals. While that is happening, the signals sent by the higher clock would move to the lower clock as the lower clock is accelerating *toward* the signals. Einstein said that the intervals between the signals received by the lower clock would be a different duration than the intervals between the signals received by the higher clock. This is because one is accelerating toward the signals, thereby cutting the time between signals, and one is accelerating away from the signals, thereby stretching the time between signals. Because of this, Einstein concluded that the clocks would run at different rates, with the higher clock running faster and the lower clock running slower.

What Einstein did in 1918 was to incorporate the higher clock/lower clock operation into describing the varying rates between clocks A and B in the paradox. But as I stated a moment ago, there is a problem with that.

As A is accelerating back toward B, right after the turnaround, Einstein considers A the lower clock and B the higher clock in a gravitational field. What gravitational field you ask? Well, remember that the principle of equivalence demonstrates that being in an accelerating elevator in outer space will produce certain effects. And those effects are identical to those experienced by someone who is in a nonmoving elevator on Earth. So, since A is in a state of acceleration after the turnaround, Einstein refers to A as equivalent to being in the "lower position" of a gravitational field. Now since Einstein presumes clock A would be like the one on the surface of the Earth, and clock B would be far away from the gravity that A is experiencing, A should see B's clock run faster and B, considered in the higher clock position, sees A's clock run slower.

What this does, is allow for B's clock to catch up to and surpass A's clock so that by the time A returns for a landing and the A and B clocks are compared right next to each other, it is A's clock that is definitively lagging behind B's. Let's examine this with some real times:

Imagine two twins: Arnie, with the A clock, who is the traveler, and Bob who remains on Earth with the B clock. You know what? On second thought, I'm sick of twins. I've read explanations on this paradox from at least a hundred different authors, and all of them, for some reason, use twin brothers. Supposedly so that it can be demonstrated during their reunification that one has aged more rapidly than the other during the experiment. But since we can assume that someone with enough technology to travel in space at speeds near that of light would also have a couple of accurate clocks to test the relative aging rates, this could really be done with any two people.

Okay, so we now have Arnie, the traveler with the A clock, and Barbara, his wife who will remain on Earth with the B clock. Arnie has just purchased a Celeritas 4000 flying machine that the dealer delivered earlier that day and has parked in the driveway. It is one minute before 5:00 pm and Arnie knows dinner is at 6 o'clock. He says to Barbara, "Honey, I'm going out for a quick test run, I'll be back in fifteen minutes." She says "okay" and off he goes. As Arnie is getting in the Celeritas, he sees that the side reads 4000 XL instead of the 4000 it read in the showroom. Seeing that everything else is identical, he doesn't think anything of it and gets in and flies off.

Now, unbeknownst to Arnie is the fact that the 4000 XL can travel much faster than the original 4000. The guy from the dealership made a mistake and gave him a prototype that Celeritas had just built. So as Arnie unwittingly speeds up to a very high constant velocity, he has no clue just how high that is. According to Einstein's Relativity of 1918, here is an account of what Arnie and Barbara's clocks would read at various parts of the journey:

A couple of minutes after achieving constant velocity, Arnie's clock reads 5:04 and he doesn't notice anything inside of his fast moving ship behaving differently other than how fast everything on the outside is whizzing past him as he speeds along. To him, his clock is running just fine since Arnie, the ship and everything in it would be considered a free float reference frame. At this time however, if Arnie had a pair of magic high-powered binoculars that would allow him to see his wife and her clock back on Earth, everything would appear to be moving in slow motion. Arnie would not only see Barbara's clock running more slowly, but time itself would be elapsing more slowly on Earth from Arnie's perspective. And as Arnie's clock ticked to 5:05, he would see Barbara's tick to 5:01.

During this same portion of the trip from Barbara's perspective, if she also had a pair of magic binoculars that could see Arnie, she would see Arnie's movements as slow motion and as her clock ticked to 5:05, she would see his tick to somewhere around 5:01. For each person, their own time would slow down from the perspective of the other person, but not from their own perspective.

This continues for a couple more minutes and then Arnie begins to decelerate, turn around and accelerate back toward Earth. Now it is during this time that the General Relativity portion of the trip kicks in and Arnie's clock is considered to be the "lower" clock in this temporarily created acceleration/gravitational field. Barbara's clock is the "higher" clock and begins to run at a faster rate than Arnie's. And, unlike the symmetry observed in the first part of the trip, where each of them observed the other's clock as moving slower – Arnie would see Barbara's time as moving faster than his while at the same time, Barbara would continue to see Arnie's time moving slower than hers.

What this means is that from Arnie's perspective when his clock ticked off two minutes (from 5:07 'till 5:09) during the deceleration/acceleration phase, Barbara's clock would be running much faster. Now remember that *before* he started the gravity portion of the trip, her clock was running behind his, just as his was running behind hers. So as his ticks from 5:07 to 5:09, hers ticks from 5:02 all the way up to 5:57! From his perspective, she went from being behind to surpassing him. She is now way ahead.

Once Arnie's velocity levels off to the constant velocity portion of the return trip, they observe the same effects as the first part of the trip. They each see each other's clock run slower again. But by this time, Barbara is already way ahead, so when Arnie arrives back home at 5:17 by his wristwatch, the clock on the wall in the dining room reads 6:04. He's late, the food is getting cold and unfortunately for Arnie, Barbara has never read a physics book in her life. You would never get this kind of drama with twin brothers.

Now you may be wondering about the initial acceleration in the very beginning (as Arnie is first leaving the planet) and the deceleration at the end when he is coming in for a landing. According to the theory, this would also have an effect in the calculation, but have an almost negligible contribution to the clock discrepancy since the h value (the distance between the two clocks) is at its lowest value of the trip, so it can be ignored.

Okay, now back to the problem. As stated earlier, there is no specific issue with the possibility that each clock could be running slower than the other at the same time.

There are plenty of things in quantum physics that defy reason but are backed up with experimental evidence. This concerns the reason *why* time slows down according to Einstein. It goes back to light signals.

As in Special Relativity, Einstein made an observation regarding the behavior of two clocks in an accelerating system covered by general relativity, based on how they transfer light signals to one another. This is the higher clock/lower clock example. A brief breakdown on the logic that Einstein used in 1911 is as follows:

First, Einstein recognized how a few observable consequences of being in an accelerating system were indistinguishable from a stationary system in a gravitational field. One example is of course the elevator in outer space where one would feel gravity pulling their feet to the floor, as long as an external force was constantly accelerating the elevator. Einstein then deemed acceleration to be "equivalent" to gravity.

Next, Einstein produced thought experiments examining the behavior of clocks and light signals in an accelerating system. He looked at energy, light wave frequency and clock rates in an accelerating system while analyzing two locations in that system. These two points were designated as S2 and S1 and were where the higher clock and lower clocks were located. Einstein described S2 and S1 as being "rigidly connected" with their distance from each other remaining fixed. Einstein derived an equation describing the extent of the energy difference and clock rate difference between these two points as they experience acceleration. The equation is: $t = t(1 + ah/c^2)$ where a is the rate of acceleration of the system. (If the word system confuses you, just think of the system as an elevator being pulled in space as a clock (S2) is attached to the ceiling and another clock (S1) is attached to the floor.) The symbol h represents the distance between the two clocks, and c is equal to the speed of light. Please note that this equation was born out of how the light signals would interact with S2 and S1 in this specific system under the given specific conditions. And of course, t = time.

Then, Einstein said that what was observed in this accelerating system would also be observed in a stationary system in a gravitational field since he had already considered the two situations equivalent. Therefore, a higher clock would run faster than a lower clock. This brings us back to Earth where a clock at the top of the Eiffel Tower runs faster than a clock on ground level. Does the Eiffel tower example resemble the accelerating system in Einstein's thought experiment? It's not identical but it's close enough. And is there any experimental evidence that corroborates the difference in clock rates? Actually, there have been a few experiments that clearly show that higher clocks run faster than ground level clocks. This includes GPS satellites that have to be time adjusted so their higher clocks can run in sync with their ground level counterparts.

This brings us back to 1918. Curiously, Einstein does not use the actual equation $t = t(1 + ah/c^2)$ to prove his case but he uses all of the language corresponding to the equation and the equivalence principle, such as higher clock, lower clock and appearance of a "gravitational field" where there is acceleration on the part of the traveler. There are a few things in this thought experiment that are different from the original application of the equivalence principle. To begin with, as there is an acceleration experienced by the traveler, the h value is not constant as it was when S2 and S1 were "rigidly connected." In many cases this may be mathematically negligible since it is divided by a c^2 value, which is a whopper of a number in the denominator of the formula's fraction, but it is worth mentioning. Next, which is a little more important, is that the relationship between the stationary clock and traveler's clock is different from a simulated gravity perspective. In the 1911 paper, S2 and S1 were rigidly connected as part of the same accelerating system. The *a* value for the acceleration (which is sometimes alternatively expressed as *g* for gravity) is the same for each clock at each location and is also described as the *a* value of the entire system. In Einstein's 1918 paradox resolution, only one of the two clocks is experiencing acceleration. Both clocks are not part of an accelerating "system." Einstein assigns a *K* coordinate system for the stationary clock, and a separate *K'* coordinate system for the moving clock. As a result, the *a* value (or *g* value if you like) is different for the two clocks during the part of the journey where the equation is used. This is a long way from 1911. Einstein defends this situation by describing an appearance of a "uniform or homogenous gravitational field" where everything in the universe is in a freefall except the traveler who is held in place by an external force as the rest of the universe accelerates toward or away from him. You know, some people have been described as having moved mountains to accomplish certain tasks. Einstein was willing to move an entire universe in freefall to keep his theory alive.

These two smaller problems contribute to the big problem that this theory has. Recall that the original system that S2 and S1 were part of, was accelerating in a particular direction, while light signals from one clock were traveling with the acceleration and signals from the other clock were traveling against the acceleration. This created an asymmetrical situation where the light signals for S2 and S1 were potentially being received at different rates and, similar to special relativity, Einstein's light signals and clock rates being interdependent on one another, one clock was determined to have to run more slowly than the other for that reason.

What Einstein did in 1918, as many others have done since, is applied the 1911 theory to the paradox where there is only one clock accelerating. This has serious implications because the pseudo gravitational field that is created is solely a result of one clock accelerating toward the other. What this does is actually create a symmetrical situation with regard to light signal communication between the clocks. As Arnie is accelerating back toward Barbara, any signals he sends to her will be read by her with the same results as how he would read her signals sent during that same portion of the trip. His moving "toward" her signals would give him the same result as what she would see as his signals are moving "toward" her. Meaning - that we would get a similar symmetrical phenomenon as observed during the constant velocity portion of the trip. The only technicality I would add here is that, Arnie would see the changing effect of his view on Barbara's clock immediately upon entering the deceleration/acceleration phase. However, Barbara's view of Arnie's clock changing effect would be somewhat delayed since the light from his deceleration/acceleration phase would take some time to reach her. The bottom line is that if we use Einstein's reasoning for why a clock slows down by consistently applying the reasoning from 1905 and 1911, when comparing two clocks in relative motion for an entire trip, we get a result different from what he proposes for the 1918 solution.

Or, if we take on the task of attempting to explain why the traveler's clock is in fact running behind the stationary clock upon reuniting, which is what the physical evidence really shows, we are forced to abandon a clock rate's absolute dependence on light signal observation and designate one of the clocks as being in a "preferred frame" for at least part of the journey.

So, to sum up:

In 1911, Einstein asserts that clocks run at different rates for two fixed points in an accelerating system because of a very specific phenomenon.

He then considers that same specific situation equivalent to two clocks in a stationary gravitational field and asserts that the two clocks will run at different rates there too.

He then creates a homogenous gravitational field and carries over the clock assumption from the previous two examples, even though these two points in this situation do not trade light signals in the specific way that explained why the accelerating system varied its clock times to begin with! Get it?

So what does all of this mean? It means that under real scientific scrutiny, the theory is inconsistent. And although it was Einstein who proposed time dilation for objects moving and/or in a gravitational field, and these predictions have been experimentally verified, his explanations for *why* these things are observed clearly does not hold up.

As you will see shortly, it is the above sub-theory involving general relativity that provided the best shot at keeping Einstein's original Special Theory of Relativity in tact. It is the only theory that attempts to explain relativity in a manner that maintains the original "no preferred frame of reference" concept, while at the same time, retains the inseparability of light signal observation and variations in clock rates during constant velocity.

Other theories that use only Special Relativity don't have any way to justify the breaking of observational symmetry while keeping the Galilean portion of Einstein in tact. Even Einstein himself admitted in 1918 that Special Relativity alone couldn't resolve the paradox.

And what about the other sub-theories that use worldlines, relativity of simultaneity and/or length contraction to explain why time slows for the traveler? Well, a special relativity worldline usually creates asymmetry during the constant velocity portion of the trip, which is in itself, a major flaw. You can't do that without making one frame preferred over the other, which is a Galilean no no. An Einsteinian would say, *well wait a minute; the traveler on the fast-moving ship would still not be able to tell that he is in motion, even while being tracked with a worldline method.* And I would remind the Einsteinian that even if that were true, the frame is still preferred since the traveler is experiencing something that the stationary person isn't. That means that the laws of physics are somehow different in the moving frame as constructed by the worldline enthusiasts. The bottom line is that, as one ship is passing another at constant velocity, time will only slow down for the ship that is considered the traveling ship. This not only renders the relative motion concept meaningless, it breaks the inseparability between observed light signals and clock rates, which is the crux of Special Relativity's reason for time dilation.

Next - Relativity of simultaneity. What relativity debate would be complete without a hot air filibuster on the relativity of simultaneity? The bottom line is that whether used alone or within a worldline explanation, you can't apply relativity of simultaneity as a solution to the paradox without creating a preferred frame. That's probably why Einstein didn't incorporate it into his 1918 explanation.

Another one of my personal favorites – Length contraction! Length contraction is actually part of the original 1905 Special Relativity paper. Some have used it as an actual explanation for why clocks slow down. Well, nice try but that's part of Einstein's relativity too. If you are trying to prove that Relativity is correct, you can't say that what's proposed in the fifth paragraph of the theory is true because what's proposed in the seventh paragraph of the same theory makes the fifth paragraph possible! Are you kidding? That's like the police picking up Bob and Harry for Grand Theft Auto and Bob says that Harry is innocent and Harry insists Bob is innocent. They were together and are both being charged. They would need a little more to corroborate their story. Any way you look at it, the length contraction creates an asymmetry during the constant velocity phase as the twin clocks do not experience dual simultaneous slowdown and therefore destroy Einstein's link between how they see each other's light and how fast their clocks run.

As you can see, the other sub-theories don't get too far before they threaten one of Einstein's original postulates. That may be one reason for the recent revival of the general relativity explanation of 1918. Physicists probably view the limitations of the other sub-theories as being painfully obvious.

So, to wrap up here, we will show that the physics community has turned relativity into a tangled web of complication that rivals the JFK assassination. The prosecution will undoubtedly try to confuse some simple issues during these proceedings, in order to divert you from the simple fact that, *they will not be able to prove Einstein is correct by sticking to the simple principles that Einstein himself published decades ago.*

As this trial unfolds, you will see that the only thing my client is guilty of is trying to teach science to students by adhering to a scientific methodology. Something that is unfortunately, not seen enough in science today.

Thank you for your kind attention.

Okay, so how was that for an opening argument? Was it easy enough to follow? I hope so. Now, if Mr. Marlor has a point, and he has shown enough inconsistency to question the validity of the entire theory and therefore, win his case, then one question we should all be asking is: What is the real reason for time slowing down in certain cases?

Recall that according to Einstein 1905 and his 1918 update, two clocks start out stationary in the same location. One clock begins to move and, after achieving a constant velocity, the moving clock will see the stationary clock slow down and the stationary clock will see the moving clock slow down. One clock changed its position with acceleration while the other clock did absolutely nothing, yet both experience a slowdown. There can be no possible mechanism that would explain a clock slowing down by doing absolutely nothing. If you subscribe to Einstein's relativity, the best you can do is describe time dilation as an inseparable co-effect of relative motion. There could be a mechanism for the time slow-down effect associated with gravity/acceleration proposed in the 1911 paper, but if we are to believe Einstein in his 1918 Twin Paradox paper, there can be no mechanism that would consistently fit with what he said in both the 1911 and 1918 papers. The slowing of time would be a concurrent effect along with comparative motion, and that would be the best we could do to explain the effect. But if Einstein's reasoning is not correct, then that opens the door for the exploration of a number of possible cause and effect relationships that fit with the experimental evidence. It is interesting to note that there are physicists who endorse the 1918 version, who pose the mechanism question. I'm not sure if they realize how limited the exploration of mechanism is within the model that they endorse.

So, what would be a starting point for exploring mechanisms, with the assumption that Einstein is not 100% correct? I think a good place to start would be the reexamination of Einstein's original reasoning during the creation of the 1905 paper. Recall that Galileo's principle declared that there was no preferred frame of reference, in the sense that motion could not, in any way, be verified within a closed, non-accelerating system. What Galileo determined about relative motion below the deck of a boat, where there was no view to the outside world, was based on evidence. Galileo found absolutely no evidence that motion could be detected, and this absence of evidence was good enough to assume that being stationary or in a state of motion was relative, and any uniformly moving system could be considered its own free-float reference frame. This, however, was all concluded with only the knowledge and evidence that was available to Galileo in the 17th century.

It was before the concept of invisible "fields" such as magnetic, electric and gravitational had been introduced. It was also before anything substantial was known about the propagation of light. Then when Einstein came along, he provided a full endorsement of Galileo's theory and said that any alternative would not make sense, with the knowledge that the only additional experimental evidence was from the Michelson-Morley experiment.

So, is there really no preferred frame of reference? Is there no absolute motion or absolute state of rest? Einstein said that there wasn't. Even decades afterward he maintained that: *The laws of physics (later phrased as laws of nature) are the same in all coordinate systems moving uniformly, relative to each other.*

A quick note about the laws of physics (or nature) being the same in a proposed moving frame as they are for a proposed stationary one. One problem is that if the statement is taken literally, it doesn't make much sense. I could say that the laws of cooking are the same in an oven set at 200 degrees as they are for an oven set at 450 degrees. Yes, the laws of cooking would be the same because they are the predetermined laws of cooking, but the food would definitely cook differently at the two temperatures.

The laws of physics could be the same for a ship docked on earth as they are for the same type of ship zipping across the galaxy because they are the predetermined laws of physics, but, like different temperatures for food, varying velocities may have a direct physical effect on the rate at which time flows.

Less literally speaking, we would take the statement to mean that all behavior inside of a moving ship is the same as what would be measured or observed in a stationary one. First of all, I don't know how anyone can claim that to be true. Even if it were true right now as I write this, it would only confidently apply to all behaviors that we are able to detect, with speeds that we are able to achieve. In fact, that very statement may be in the process of being disproved. One physicist who has been questioning the possible limits of relativity is Dr. Alan Kostelecky of Indiana University. Kostelecky thinks that there are relativity violations waiting to be discovered due to the existence of a fixed backdrop of vectors which objects move through. Some day, a sensitive enough experiment may be developed and conducted on a fast moving ship that will indicate the extent of that ship's *absolute* motion. I think that it is an idea worth exploring. In fact, any further exploration of a system of moving particles and the environment in which they move would be a step in the right direction.

It doesn't make sense why scientists have not pursued a cause and effect mechanism for time dilation by investigating a possible relationship between the moving particles and their immediate local environment. This is where I think that the physics community took its crucial wrong turn. Or, in this case, stayed on the wrong road while failing to make a right turn.

What I mean by all of this is that if there is any mechanism whatsoever responsible for a specific clock running more slowly than it did before it increased velocity, then there must be a cause for that effect. There is no way around it. And the cause would have to occur as the clock is changing velocity, or is maintaining a higher velocity, or both.

This is the line of investigation that has been ignored in the never-ending quest to understand the true nature of time. Probably because, to admit that there is a real physical cause wrapped somewhere in the velocity or acceleration would be at the very least, a partial abandonment of Einsteinian Relativity.

So, how could we begin to describe how time slows down? My suggestion is that we should be looking at any relationship that exists between moving particles and the environment(s) they exist in. Remember, if I go on a high-speed journey, somewhere along the line time starts to run more slowly. Not just my clock, but time itself. Every physical action on my speeding ship slows down, such as my heart rate, my movements, the mechanical workings of the ship, and so on.

So, to me, it would seem natural to wonder if there is a common denominator to all of this particle behavior. Is the rate at which a heart beats, a clock ticks, and an atom decays radioactively, governed by some common underlying fundamental behavior? Are there some fundamental behaviors taking place on the quark and lepton level that are happening perhaps quintillions of times a second, that could dictate the rate at which other events happens once on a more visible level? (By the way, atoms are made of electrons, protons and neutrons, and the protons and neutrons are made of quarks. Electrons are classified as leptons. There, we're caught up.)

What if time itself is nothing other than one or more of these fundamental subatomic behaviors repeating themselves? In other words, could the rates of these behaviors be what dictate other large scale behavior rates that eventually coalesce into a macro scale rhythm that we "perceive" from moment to moment as a stream of events?

And what if these fundamental behaviors, that may be taking place on the quark and lepton level, can be sped up or slowed down? What if all of these particles, that happen to be swimming in invisible fields such as electromagnetic, electric, gravitational (whatever that is) along with other possible fields, such as a Higgs field, have a working relationship with at least one of these fields that they are in? And what if part of the relationship between field and particle is that the field plays an actual role in determining the rate at which the fundamental behavior takes place? And what would be the possibility that if one were to disturb the location of a particle with respect to a surrounding field, that it could alter the rate at which the particle engages in one or more of these fundamental behaviors?

To me, the issue is that simple. If the rate at which time elapses can be linked to some sort of physical mechanism, then the mechanism would have to be engaged during both movement and while in a gravitational field. By looking at time in this way, we might be able to kill two birds with one stone. First, establishing what time itself actually is, and second, determining what causes time's rate to fluctuate.

Before I continue with particles and fields, I need to mentioned forces. There are four known forces in the universe. *Electromagnetic* (which allows your socks to static-cling together) *gravity* (which allow your socks to fall to the ground if you let go of them) *strong force* (which has to do with holding protons and neutrons together in an atomic nucleus with something called gluon transfer) and finally the *weak force* (which is observed during beta decay, which simply means radiating off electrons.)

While considering particles, fields and forces, a possible mechanism could be that the movement of particles with respect to their fields could be having a direct effect on the rates of certain behaviors that we are already aware of. Some examples that could be investigated are specific behaviors on the quark level, such as quark flavor change and gluon transfer. Quarks, which make up protons, neutrons and other particles, come in several varieties. Part of the classification system is to categorize them into sub-quark groups and assign "flavor" names and "color" names to distinguish the different types. (Much like charged particles were designated as "positive" and "negative" a long time ago in order to distinguish like charge from opposite charge.)

Consider some atoms (viewed as a group of quarks) that are moving at a high velocity through a background field of some sort, while dragging one or more of their own fields along. This simple activity could have a physical effect on the rate at which a quark can engage in flavor change, along with other behaviors that could slow the rate of an overall behavior which defines what time is. The trick is to find a mechanism that can explain all larger scale behaviors. Having said that, there may be a possibility that all behaviors aren't affected equally. Some particles may even be immune to time.

A particle behavior already known to many relativity enthusiasts is the decay of the muon, which is a member of the lepton family. A typical muon will exist for about two microseconds until it decays into an electron and two other particles called neutrinos. This is actually accomplished via the weak force, in which a particle known as a W particle is generated to facilitate the decay. (The W particle is also involved in quark flavor changes too.) Now, if we were able to examine those precious two microseconds closely, what would we find? Is there a fundamental behavior, taking place once or repeating itself many times over during the two microseconds that causes the actual decay? And can this fundamental behavior in the muon be sped up or slowed down if the muon experiences a velocity change and/or position change in a gravitational field? Could a moun, moving at extremely high velocity, take longer to produce a W particle, or have a longer-lived W particle, or some other behavior, simply because it has a higher velocity relative to some background field or is placing a strain on a field of its own that is being dragged along?

We should view the muon's two-microsecond life as we would view a pot of water's five minutes on the burner before it begins to boil away. Something is happening during those five minutes. A gradual change is taking place that brings the liquid water to an eventual state of gaseous, non-liquid existence. Similarly, something is happening during the muon's two microseconds. Is it something gradual, due to an energy change, as we see with the boiling water? Or is it one, single, very quick rate-determining event that just has a high probability of occurring at around two microseconds? In either case, something is definitely happening during high velocity and/or exposure to gravity that is prolonging this event. During high velocity, a disturbance could be created between the muon and one of its own fields, or a field it is moving through. Gravity could be creating the same net effect by having an influence on a background field, or one of the muon's own fields, as the muon remains stationary. In either event, this disturbance could be the equivalent of moving the pot of water off of the burner by a centimeter, which would prolong the boiling time.

Now remember, this is just a muon example we are using here. In reality, a system of particles moving at high velocity, experience a universal slowing of all activity. All electromagnetic, strong and weak behaviors that experience time should be affected by velocity or gravity.

For years, physicists have been trying to unify all of the forces. If these forces are as linked to each other as physicists hope they are, then it should be no surprise that they would all be similarly affected by time slowing mechanisms. I am Hopeful that in the very near future, we will learn more about how the various particles, fields and forces affect one another so that a "time" mechanism can be established.

Before I bring this to a close, I would like to revisit the relativity trial. You have already read the opening statement that I would give if this were ever presented as a case in a court of law. I wouldn't want to cheat you and not give you a glimpse of what a scene with an expert witness, being cross-examined on the witness stand would be like. So, here is a bit of dialogue between myself and one of the state's expert witnesses as I cross-examine him after he has just given testimony to the State District Attorney:

CK: Good afternoon, Dr. Stipeck.

Dr. Stipeck: Good afternoon.

CK: Am I pronouncing your name correctly, sir?

Dr. Stipeck: The "t" is silent but you are pretty close. Much closer than you would have been if you were speaking with my grandfather. Back then the family name was still Stipeckzolinis, that is, until the folks at Ellis Island got a hold of it.

CK: Well, you can always change it back, but please, not until I'm finished with my cross-examination!

(Laughter)

Dr. Stipeck: If it makes things easier, many people call me Dr. S.

CK: Then Dr. S it is. Thank you. Now, just so the jury understands, you are obviously an expert witness with regard to the physics of relativity, but also expert in the engineering applications of Global Positioning Satellite systems. And that's why during your examination, you were permitted to describe with some detail, GPS as a real-world example of relativity applications – is that correct?

Dr. S: Yes, in addition to being a physicist, I have served as a consultant to satellite manufacturing companies.

CK: Terrific. And so, since relativity and GPS technology were opened as a line of questioning, with regard to you as a witness, I am going to ask you questions in both areas.

Dr. S: That would be fine.

CK: Now Dr. S, you mentioned in your testimony a moment ago, that it is the 1918 version of relativity that you endorse, is that correct? The version where the traveler and the stationary observer each experience a time slowdown from the perspective of the other?

Dr. S: Yes, that's right.

CK: And within that version, you would agree that applications of both special relativity and general relativity are used in attempt to explain clock discrepancies?

Dr. S: Well, I wouldn't call it an attempt. I would consider it a thorough scientific explanation of why a moving clock would be running behind a stationary one upon comparison when they reunite.

CK: Well then, is there an example of an experiment that provides proof that that is what is happening?

Dr. S: Well, there are plenty of experiments that show time dilation due to both general and special theory applications. There is…

CK: Well, that's not what I asked you doctor. We are all aware of exper..

DA: Objection, Your Honor. He is not allowing the witness to finish his answer.

CK: Your Honor, with all due respect, Doctor Stipeck was not answering my specific question. We are not disputing the fact that time slows down during relative velocity or in a gravitational field. But the relativity theory of 1918 lays out a specific sequence of events as an explanation for why a traveler's clock will be behind a stationary clock after unification. To be clear, my question is: are there any experiments that the doctor is aware of, that verify the specific sequence of events claimed to take place in the 1918 theory?

Judge: Overruled, the witness will answer the question.

Dr. S: No, but it has been proven mathematically.

CK: You're sure about that?

Dr. S: Yes.

CK: How can you be that sure? I mean, I could prove mathematically that my necktie has negative length or that my falling pen will never hit the ground. Isn't it possible that a good mathematician could create an outcome to fit a desired result?

DA: Objection, the witness couldn't possibly be expected to read the minds of the scientists who used these equations to prove this theory. The witness was already asked if he was sure, and he responded with a yes.

Judge: The objection is sustained.

CK: That's fine your Honor. Okay Doctor, how about if we move on to GPS?

Dr. S: Sure.

CK: Now, in your testimony earlier, you stated that GPS is a great example of a real-life application of relativity, because it has to consider special and general relativity – is that correct?

Dr. S: Yes, that's right.

CK: And this is because the motion of the satellites that are about 11,000 miles off of the ground can have measurable relativistic effects on the very sensitive atomic clocks that are carried by these satellites?

Dr. S: That's correct.

CK: You also mentioned that the relativity effect is so real, that if it were ignored, the satellite clocks would run faster than the ground clocks, and in a very short period of time, the difference in clock times would produce enormous discrepancies when calculating positions of objects, right?

Dr. S: Yes.

CK: Doctor, I wonder if you could walk us through that. Could you give us some specifics regarding to what extent each phenomenon has on the clocks?

Dr. S: Sure. General Relativity says that the higher you are in a gravitational field, the faster your clock will run. In the case of GPS satellites, which are about 11,000 miles high, this comes out to be a clock rate of 45,000 nanoseconds per day faster than the clocks on the ground. With a billion nanoseconds equaling one second.

CK: 45,000 nanoseconds? Wow! What a whopper of a difference huh? If I were 45,000 nanoseconds late for dinner, my girlfriend might not even get mad at me!

Dr. S: *(Laughs)* maybe not, but a satellite clock being off by just 1000 nanoseconds can create a noticeable error in calculating an object's position. That's why they are equipped with accurate atomic clocks to begin with. Anything less accurate, and the GPS system wouldn't be very useful.

CK: So how do the scientists compensate for the 45,000 nanoseconds per day?

Dr. S: Well, it's not really 45,000 nanoseconds that the clock is off by. It's actually 38,000 nanoseconds.

CK: Why is that?

Dr. S: The General relativity factor is what causes a satellite clock to run 45,000 nanoseconds faster. Meanwhile, the special relativity factor, from the constant velocity of the satellite, causes its clock to run comparatively slower by 7,000 nanoseconds per day. Put the two together, and you get a net result of satellite clocks running faster by 38,000 nanoseconds per day.

CK: Okay, just so we are sure we understand what is going on here: if, for example we lived in a universe where gravity did not have an effect on clock rates, but velocity did - then the satellite clock would be running slower than our clocks on the ground, right?

Dr. S: Yes, by 7,000 nanoseconds per day. As I said before, the extreme altitude of the satellite causes its clock to run 45,000 nanoseconds faster, while at the same time, the velocity of the satellite causes its clock to run 7,000 nanoseconds slower. Combining the two effects by subtracting 7,000 from 45,000 produces a net result of 38,000 nanoseconds faster per day compared to our clocks on the ground.

CK: So, if the clocks need to be more accurate than this discrepancy that relativity seems to be creating, how do the engineers deal with this problem?

Dr. S: They actually offset the rate of the satellite clock before they launch it into orbit. Specifically, they make it run a little bit slower. As a matter of fact, 38,000 nanoseconds per day slower.

CK: And this does the trick?

Dr. S: Yes, this makes the satellite clocks run in sync with the ground clocks. There is still a tiny error from time to time, but for the most part, it is kept below a difference of a few hundred nanoseconds.

CK: So, I have a GPS receiver in my car and the satellites can determine where on this entire planet I am located with their clocks?

Dr. S: Well essentially, yes.

CK: Can you explain to the court how that is done?

DA: Your Honor, is this really necessary? We have already established that….

CK: Your honor, the prosecution introduced Dr. Stipeck as an expert witness, and it was they who chose to use GPS technology as a real-life example of Einstein's relativity. I don't think it would be asking too much, to take a few moments and educate the jury a little more on how the GPS clock system works, so they can actually understand the application of this real-life example.

Judge: Mr. Kennedy, frankly, I don't see how this will help your argument, but I will allow you to continue. Let's not get lost in this stuff, okay?

CK: Yes, Your Honor. Thank you. *(pause)* Doctor, without getting too technical, can you explain how *(holds up a GPS receiver)* the GPS system can determine where my location is if I've got one of these.

Dr. S: Yes. It deals with the process of elimination. If you were standing in the middle of a field, for example, and someone told you that there was a buried treasure exactly twenty feet from where you were standing, then with only that information, you would have to do a lot of digging to find the treasure.

CK: Unless, of course, I were really lucky!

Dr. S: *(laughs)* Yes, you would need an enormous amount of luck. Because you could walk exactly twenty feet in any direction and the treasure could be in any one of those spots. In fact, you could trace a complete circle around your position and every point on that circle would be exactly twenty feet away from you. The treasure could be buried below any point on that circle.

CK: Okay, continue.

Dr. S: Now, if you had another person out in the field with you who was fifty feet from you, and now the clue is that the buried treasure is twenty feet from where you are standing, but is thirty-five feet from where the other person is standing, you can now narrow the treasure's location down to only two possible spots. Even if you were unlucky, at the most you would only have to dig in two places before you found the treasure.

CK: I see where you are going with this, proceed.

Dr. S: Now if we add a third person to the field, and he is standing about fifty feet from you and also fifty feet from the other person, the three of you would form a triangle. And if the new clue said that the buried treasure was exactly twenty feet from you, thirty-five feet from the second person and thirty-eight feet from the third person, there is now only one possible position that could be true for that combination of relative positions. By the time we introduced the third person as a distance reference, we have eliminated all possible positions but one. That is where you would find the buried treasure.

CK: And satellites work the same way?

Dr. S: Yes, at any given time, there are four satellites in different positions in the sky, much like there were three people standing in different positions in the field. And when you are driving down the road, the GPS receiver, like the one you are holding can calculate its distance from each of the four satellites. From that, it can determine the receiver's only possible location, based on the unique combination of satellite distances for that moment.

CK: And how does it do that?

Dr. S: Well, that's where the accuracy of the clocks is crucial. They really need to be in sync to within about a couple hundred nanoseconds. What happens is that each of the four satellites sends time signatures at very regular intervals to GPS receivers on the ground.

CK: A receiver like this one? *(holds up receiver again)*

Dr. S: Yes, that's right. And for example, when it is exactly 12 o'clock, and when I say 12 o'clock, I mean with an accuracy of a couple hundred nanoseconds, each satellite will send a coded message indicating "exactly 12 o'clock." Now, the "exactly 12:00" signal will take some time to get from the satellite to the ground. And because the signal travels at a known speed, the speed of light, the distance between a satellite at a known position in the sky, and a receiver on the ground, can be calculated.

CK: The speed of light being 186,000 miles per second, right?

Dr. S: Yes. So, if the precise 12:00:00 signal, reached a receiver on the ground at exactly 12:00:01, which is exactly one second after noon, then we know it would have taken the signal exactly one second to travel from satellite to receiver, and with a velocity of 186,000 miles per second, we could deduce that the satellite must be exactly 186,000 miles from the receiver.

CK: I think I'm getting this. So, if the exact noon signal registered on the receiver clock at a half a second after exactly noon, we know it would have come from a distance that would correspond with a half second of travel time which would be, I'm guessing 93,000 miles away?

Dr. S: Right. Since light needs one second to travel 186,000 miles, then a half second would correspond with a distance that is half of 186,000, which is 93,000 miles. Now, in the case of the GPS satellites, they are about 11,000 above the earth, so we are dealing with times much shorter than one second. And, once the receiver calculates distances from four different satellites, with that info, a unique, accurate position can be calculated for the receiver.

CK: So to give an exaggerated example of how important clock accuracy is, If one of my satellite clocks were running too fast by a tenth of a second, then when it was really exactly noon, at that time, the satellite clock would erroneously read 12:00:00:1. And let's say that the satellite is not 11, 000 miles up but 18,600 miles up, so that it would take a tenth of a second for the signal to travel from the satellite to the ground.

Dr. S: Okay.

CK: Then, when the erroneous 12:00:00:1 signal, sent at exactly noon, reached the receiver's clock a tenth of a second later, and the receiver's own clock correctly reads 12:00:00:1 at the time the signal arrives, then the receiver would incorrectly conclude that the signal took no time at all and that the satellite, which is really thousands of miles up in space, is right on top of the receiver?

Dr. S: Yes, that's why we measure clock accuracies in nanoseconds, which as I mentioned earlier are each one-billionth of a second.

CK: That is a pretty sensitive clock indeed. Now with that accuracy requirement, you mean to tell me that they don't slip off track even a little bit?

Dr. S: Actually, if left unchecked, they can slip off track, or more appropriately, out of sync. What happens is that since the receiver clocks are quartz clocks, they are less accurate than the atomic clocks inside the orbiting satellites. So, the satellites will send periodic corrections to the receiver clocks, in order for them to all remain in sync.

CK: I see. Do you ever worry about the satellite clocks slipping off track?

Dr. S: That happens too.

CK: How big of a deal is that?

Dr. S: Well, a drift of even 500 nanoseconds could produce a position error of up to about 70 meters. For more precise GPS applications, that is completely unacceptable. Fortunately, for the most part, the drift doesn't exceed 70-100 nanoseconds, which correspond with a position error of about 10-15 meters.

CK: How is the clock drift kept in those ranges?

Dr. S: There are ground control stations that monitor the satellite clocks for accuracy. As accurate as the satellite clocks are, the atomic clocks on the ground, such as the clocks at the station in Colorado Springs are even more accurate. They are constantly keeping track of the "official time" here on earth. Typically, each orbiting satellite will get a correction from a ground control clock twice a day. The correction doesn't change how the satellite clocks run per se. It's more of a code of information to allow the receivers to interpret the accurate "actual" time, given the known error of the reported time by the satellite.

CK: And in between maintenance corrections from the ground stations, the clocks on their own, stay within say a couple hundred nanoseconds?

Dr. S: Yes, and usually much more accurate than that. When the ground stations send the corrective information, they also send information to pre-compensate for other error sources the satellite will anticipate, like slight shifts in the satellite's orbits and the signal's varying speed when traveling through the ionosphere. A satellite can also dispatch corrections to other satellites too. By no means is the satellite clock broadcasting an "exactly noon" signal. A better way to look at it is that it is sending corrected coded information that the receivers can interpret as exactly noon. I can also tell you that there are GPS field manuals that use what is called a URA index for accuracy. When a satellite immediately receives a corrective update from a ground station, its URA index value can be pretty close to zero. On average, between corrections, it can range from an index of 2 to 5, A 5 corresponds with a clock drift error of around 100 nanoseconds and produce a position error of around 13 meters.

CK: And when that particular satellite receives another corrective adjustment twelve hours later, its index will go back to being much closer to zero again?

Dr. S: That's right.

CK: Well, I think we have a problem then, don't we doctor?

Dr. S: None that I can see.

CK: Well, getting back to relativity for a moment, you said that you agree with Einstein's 1918 version of relativity, that states a stationary person would see a traveler's clock as moving slowly, while at the same time, the traveler would see the stationary clock as moving slowly. And those who endorse this theory make it pretty clear that this is no optical illusion. They make it very clear that in order for this theory to work, each person's passage of time itself, really slows down from the perspective of the other. That is what you endorse, right doctor?

Dr. S: Well, I thought we already covered this, but yes, that is what would happen.

CK: Then can you explain why that doesn't happen with GPS satellite clocks?

Dr. S: I'm sorry, I'm afraid I don't understand your question.

CK: Doctor, can you tell us, forgetting about the gravity component for a moment, why the moving satellite clocks run 7,000 nanoseconds slower than their stationary counterparts on the ground, but the ground clocks don't simultaneously run 7,000 nanoseconds slower from the perspective of the moving satellite clocks – you know like the 1918 theory states.

Dr. S: You must be confused. In reality, even though GPS clocks verify special and general relativity, and the ground clocks continuously track the satellite clock rates, the satellites don't "track" the ground clock rates, so they wouldn't know or care what the ground clocks are doing in order to serve their purpose. So, I'm afraid we can't see the ground clock rate from the perspective of the satellite because there is no satellite perspective.

CK: With all due respect doctor, are you sure that's correct?

DA: Objection, Your Honor. I think we have heard enough of this nonsense.

Judge: Mr. Kennedy, for the last time, what is it that you are trying to accomplish?

CK: Your Honor, my client is on trial here and his entire professional career hangs in the balance. Now, I have a question out there that Doctor Stipeck has not provided an acceptable answer to. I'm sorry, but it was the prosecution who declared this man to be an expert witness in the areas of relativity and GPS technology. I was about to give the doctor another opportunity to answer correctly.

Judge: I will allow this, but I caution you Mr. Kennedy, you are treading on some thin ice here.

CK: Thank you, your Honor. Doctor, did you not, a moment ago, say that when a ground station uploads clock correction data to a satellite, at that moment they would have a URA value close to zero, meaning that at that moment, they would be pretty much in sync?

Dr. S: Yes, with the correction data.

CK: So, if a correction transfers at say, exactly 1:30:00 pm, then both clocks would represent times that are within a few nanoseconds of each other after that upload is implemented, correct?

Dr. S: That's correct.

CK: Didn't you also say that the satellites send their time signatures to the receivers on a very regular basis? So, for all practical purposes, since the receiver is getting a continuous real-time feed of the satellite clock times, then the receiver could serve as an ongoing "report" of what time it is from the perspective of the satellite, couldn't it?

Dr. S: *(Long pause)*

CK: Doctor?

Dr. S: I suppose.

CK: Is that a yes, Doctor?

Dr. S: Yes.

CK: Now, Doctor, earlier you agreed with my statement that if there were no cause and effect relationship between gravitational position and clock rate, then an unadjusted satellite clock would only be off by the 7,000 nanoseconds a day, due to the special relativity effect of the satellite's constant velocity, right?

Dr. S: That's right.

CK: So, if a satellite clock were adjusted before launch to run, not 38,000 nanoseconds slower like the ones in GPS, but the exact gravity offset, which is 45,000 nanoseconds slower, then it would be as if gravity were no longer a factor when comparing the ground clocks with the orbiting satellite clock, isn't that correct Doctor?

Dr. S: Yes, that's right.

CK: And so, what would we observe? Would the clocks be running in sync?

Dr. S: No.

CK: Then from our perspective on earth, would we see the orbiting satellite clocks as running slower by 7,000 nanoseconds per day?

Dr. S: Yes.

CK: And if we had the means to measure this sort of thing, wouldn't we also observe the ground clocks as running 7,000 nanoseconds per day slower, from the perspective of the satellites?

Dr. S: *(Softly)* Yes.

CK: I'm sorry doctor I couldn't hear you.

Dr. S: Yes, we would.

CK: So, compared to this effect that we just discussed with a 45,000 nanosecond adjustment, can we now reexamine the observed effect of the 38,000 nanosecond adjustment from the perspective of each? *(Pause)* In other words, we've got a satellite already in orbit, and its clock is running 45,000 nanoseconds per day slower. When that is happening, according to you, people on the ground would detect a satellite clock as running 7,000 nanoseconds per day slower than their own clock, and at the same time, if there were an astronaut riding around on the satellite, he or she would detect the ground clocks as running 7,000 nanoseconds per day slower than the atomic clock on his satellite. So now we speed up the satellite clock by a rate of 7,000 nanoseconds per day. It was running 45,000 nanoseconds slower, but by speeding it up by 7,000, it is now only running 38,000 nanoseconds slower. From my perspective on the ground, how do I now view the satellite clock?

Dr. S: It is now running in sync with the ground clocks.

CK: Because we sped it up by the exact rate that it was running slower, right Doctor? In other words, we have compensated for the special relativity effect, right?

Dr. S: Yes.

CK: Now, regarding the satellite's perspective of the ground clock rate, before the last speed-up, the satellite clock viewed the ground clocks as running 7,000 nanoseconds per day slower. After we speed up the satellite clock to run 7,000 nanoseconds faster than it did previously, how would the satellite view the ground clock after that, doctor?

DA: Objection.

Judge: Overruled. The witness will answer the question.

Dr. S: According to the 1918 theory, the satellite would then view the ground clocks as running 14,000 nanoseconds per day slower.

CK: Because the ground was already 7,000 nanoseconds behind, then when we make the satellite run faster by 7,000 nanoseconds, the ground rate is now 14,000 nanoseconds per day slower than the satellite, right?

Dr. S: Yes.

CK: So to be sure we all understand correctly, the way the GPS satellite clocks are running right now, in real-life so to speak, which I will remind the court, **is** 38,000 nanoseconds per day faster - they are, within reason, running in sync with the ground clocks. While at the same time, if we had the means to measure the ground clock rate from the perspective of the satellites, we would find the ground clocks running slower by 14,000 nanoseconds per day. Do I have that correct, doctor?

Dr. S: Yes.

CK: Kind of sounds a bit like science fiction, don't you think?

DA: Objection!

CK: I withdraw the question. Okay, at this point, I would like to go back to the satellite clocks being periodically corrected by the ground control station, like the one in Colorado Springs. You said that if Colorado Springs sent an upload at precisely 1:30:00 pm, then right after that, the official clock at Colorado Springs would be in sync with the satellite clock, or at least within a few nanoseconds right?

Dr. S: Yes.

CK: And you also said that there would be additional corrections along the way, before it encountered another ground station correction 12 hours later, right?

Dr. S: Yes.

CK: Doctor C, would it be safe to say that these corrections keep the satellite clock closer to being in sync with the ground clock.

Dr. S: Yes.

CK: So, the correction codes sent to the ground receivers represent what the ongoing relativity adjusted satellite time is by minimizing or compensating for any errors that drift the clocks off of their desired rate, right? I mean, if we didn't have little nuisance errors from things such as orbit irregularities, the relativity adjusted satellite clocks would remain within a couple hundred nanoseconds of the ground control clock in Colorado for much longer, right? Couldn't we look at that in that way?

Dr. S: Sure, I guess you could look at it that way.

CK: Okay, so, then from the ground, we would know when it is 1:30:00 pm satellite time, right doctor?

Dr. S: Yes.

CK: And from the ground, we know when it is 1:31 satellite time, and 1:32, and 1:33 and so on, because the ground receivers are constantly getting time signature codes from the satellites on a very regular basis, right doctor?

Dr. S: Yes, that's right.

CK: And earlier, doctor, you said that we can't know what ground clock rates are from the satellites perspective because the satellites don't read times, they just give off times for ground clocks to read. Is that what you said?

Dr. S: Yes.

CK: But doctor, while it is true that the satellites don't "read" ground rates, wouldn't we know, for example, that at exactly 1:30 pm satellite time, it received a correction from the ground control station that indicated that it is also, exactly 1:30 on the ground?

Dr. S: Yes.

CK: And for the next twelve hours, I'm receiving ongoing, real-time satellite times, aren't I, doctor?

Dr. S: Well, yes, I guess you are.

CK: So, the satellite clock keeps running and the receivers get ongoing representations of what time it is on the satellite. Now we fast-forward twelve hours, and it is exactly 1:30 am satellite time. If the satellite gets its next correction upload from ground control, will the correction adjustment be within, say, a couple hundred nanoseconds?

Dr. S: Of course it would.

CK: Well, I guess we are back to our problem then, aren't we? Forgive the crude thought experiment doctor, but let's say I were on the satellite at exactly 1:30 pm, satellite time. I then take a photo of the ground control clock on Earth, and the photo shows the Earth clock as reading exactly 1:30 pm. Do you follow so far, doctor?

Dr. S: Yes.

CK: And satellite time is ticking away until we get to exactly 1:30 am. During that twelve hour period from the satellite perspective, will the ground control clock also elapse exactly twelve hours, or will it be a little less since it is running a little slower?

Dr. S: Well, if the satellite were to return to Earth, the correct solution to the twin paradox is that…..

CK: Doctor, that is not what I asked. A component of special relativity, whether we are applying it to the twin paradox or not, is that all motion is relative. There is no absolute motion. A guy on Earth could claim that a spaceship was whizzing past him, while at the same time, the guy on the spaceship could claim that the Earth was whizzing past his ship. And it was Einstein's contention, that during that time, the guy on Earth would see the spaceship's clock as running slower, and the guy on the spaceship would see the Earth's clock as running slower. Not as some illusory effect, but because time itself has simultaneously slowed down for each, from the perspective of the other. I will remind you that what happened after that was that several scientists constructed mathematical "proofs" that show how the acceleration phase of the spaceship's journey, will compensate exactly, for the simultaneous slowdown effect during the constant velocity portion of the journey. And if these mathematical "proofs" are correct, then Einstein's original theory remains correct and agrees with experimental evidence. But, thank heaven for GPS, right doctor? Because in this case, we are not trying to piece together how much clock time drifted during each portion of a trip between, say, an airplane and the Earth after the airplane and its atomic clock has returned. With GPS we now we have a way to test the relative time of two objects while each of them remain in a state of relative constant velocity, with respect to the other. In other words, we can isolate that portion of the "twin paradox journey" and put it to the test. So, I will ask you again doctor – If twelve hours have passed, which is half of a day, and it is 1:30 am on the satellite clock, and the satellite takes a second picture of the ground clock, will the picture show a ground clock also reading exactly 1:30 am, or will the picture of the ground clock show a time that is 7,000 nanoseconds short of 1:30 am?

Dr. S: *(long pause)*

CK: Doctor?

Dr. S: The picture of the ground clock *(pause)* would have to show a time *(long pause)* that is short of the 1:30 mark, since its clock would be running slower from the satellite's perspective.

CK: Thank you, doctor. Now doctor, you are a physicist, can you tell us how a camera works?

Dr. S: Well, a basic camera would be nothing more than a device that was capable of making a somewhat accurate record of an image.

CK: So, a basic thirty-five millimeter, for example, would focus on an object, and light waves coming from that object that correspond to its shape and various colors, would reach the camera, and the moment the shutter opened, would be recorded on the film inside the camera, correct?

Dr. S: Essentially, yes.

CK: So, any object that is capable of generating or reflecting an adequate amount of light signals, with information corresponding to its image, can send those signals to a camera, which will record them, correct?

Dr. S: Yes.

CK: A camera receives and records visible spectrum light signals that are electromagnetic in nature and travel the speed of light, and a satellite receives and records correction data in the form of non-visible signals, but like light, are signals that are part of the electromagnetic spectrum and travel at that same light speed. Doctor, could we look at the satellite's capability of receiving and recording signals from the ground control station as being not too different from how a camera operates?

Dr. S: I guess you could look at it that way.

CK: When a ground station uploads correction data to a satellite, the extent of the correction is based on what time it is on the ground at that precise time, right doctor?

Dr. S: Yes.

CK: So the satellite gets a signal at 1:30 am satellite time, that it can pass along to the receivers *(holds up receiver)* that is essentially telling the satellite what time it is at the precise atomic clock in Colorado, when it is exactly 1:30 on the satellite, right?

Dr. S: Yes.

CK: And that new correction, implemented right after upload, will be the newly corrected satellite time, right?

Dr. S: That's right.

CK: Well then, doctor, *(Pause)* Considering the fact that an adjusted satellite clock and the precise atomic clock in Colorado are in sync at the time it receives an upload at 1:30 pm, which again, is like the satellite taking a photo of the ground control clock at that time, and considering the fact that the adjusted satellite clock and the ground control clock are running within, say, a few hundred nanoseconds of each other for the span of the next twelve hours - when the satellite takes its next picture – excuse me, receives its next upload from the ground control station, is it sent a new correction that suddenly sets it back 7000 nanoseconds from what its corrective information represented just before that upload?

Dr. S: *(pause)*

CK: Doctor?

Dr. S: *(pause)*

CK: So, tell me Doctor, how do you like your relativity of simultaneity now?

DA: Objection!

Judge: Sustained.

CK: Sorry. But surely, you must see the contradiction, don't you Doctor? The satellite is receiving a clock time from the ground, and we know when the satellite is receiving it. Twelve hours go by for the satellite, and it receives another corrective upload based on the clock time on the ground. If Einstein's 1918 theory is correct, then we should observe the satellite getting a second corrective upload at precisely 1:30 a.m. satellite time, with corrective information that corresponds to a ground control clock reading of somewhere in the neighborhood 7,000 nanoseconds behind the correction representation on the satellite immediately before the upload, because the 1918 theory says that the ground clock should be running slower from the perspective of the satellite. But that's not what happens is it Doctor? It turns out that when the special and general relativity adjustments are made, the satellite clocks not only run within nanoseconds of being in sync with the ground clocks, but the ground clocks run within nanoseconds of being in sync with the satellite clocks, right doctor? If the 1918 theory were correct, each upload would actually set back the satellite clock correction codes by thousands of nanoseconds. The GPS system, as we know it, would not be able to function would it Doctor?

Dr. S: *(Looks down, says nothing)*

CK: That's okay Doctor, you don't need to answer if you don't want to. Your Honor, I have no further questions.

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