

## Re: time dilation

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- *From:* [mitchgrav@xxxxxxxxxxx](mailto:mitchgrav@xxxxxxxxxxx)
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On Apr 10, 5:39 pm, Darwin123 <drosen0...@xxxxxxxx> wrote:

On Apr 10, 7:40 pm, rbwinn <rbwi...@xxxxxxxx> wrote:

The work of famous scientist Galileo Galilei provides us with a question about time dilation and Dr. Albert Einstein's statement that the laws of physics must remain the same in all frames of reference. Galileo carried two lead weights of unequal sizes to the top of the leaning tower of Pisa and dropped them at the same time, disproving the idea of scientists of his time that the heavier of the two weights would strike the ground first. Of course, it took some time before scientists accepted the results of his experiment. They did not all believe in the principle of equivalence the moment the two lead weights hit the ground.

This brings us to another question about falling objects which arises from the idea of dropping an object in a moving train car, which writers of textbooks about relativity often use to show how the Lorentz equations work. If a weight is dropped from the top of a train car to the floor, it falls a distance of  $y'$ . In any transformation equations this is always expressed as  $y'=y$ . The object travels the same distance vertically in  $S'$  as it does in  $S$ . In Galileo's equations, it takes the same amount of time for the object to travel from the roof of the train car to the floor in either frame of reference.  $t'=t$ .

In the Lorentz equations, a clock in  $S'$ , the frame of reference of the train car, is slower than a clock in  $S$ , the frame of reference of the train tracks.

$t'=(t-vx/c^2)/\sqrt{1-v^2/c^2}$ . According to this equation, it takes less time for the object to fall from the roof of the train car to the floor in  $S'$  than it does in  $S$ . So how are the laws of physics the same in both frames of reference?

Well, the law of physics is the same in both frames.  
In your case, the initial conditions are different.  
In  $S$ ,

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$$2at = \sqrt{1 - v_0^2}$$

In S',

$$2a't' = \sqrt{1 - v_0'^2}$$

In your example, the boundary conditions are the same. In other words, the distance from roof to floor is the same in both frames.

Obviously  $v$  is not  $v'$ ,  $v_0$  is not  $v_0'$ , and  $a$  is not  $a'$ . One has to perform a Lorentz transformation on each quantity. However, the equation (i.e., the law of physics) is exactly the same.

The laws of physics are the same in the two frames. The initial and boundary conditions do not have to be the same in the two frames.

If you want to include force laws, you have to Lorentz transform the forces. In SR, the transformation of the gravitational field is exactly the same as the transformation of an electromagnetic field. Therefore, when you transform the gravitational field you will get a gravitomagnetic field, which is analogous to the magnetic field. The gravitomagnetic field is what transforms turns  $a$  to  $a'$ . However, both S and S' describe the drop with the same equations. The S' frame may use a zero gravitomagnetic field, while the S frame has a nonzero gravitomagnetic field.

I know, some purists will say it is a GR problem and to some extent I agree. I just wish to point out that SR is a valid approximation in this case.

The accurate laws of physics are the same in S and S', because the most accurate laws are Lorentz invariant. If you use a law that isn't Lorentz invariant (like  $a=a'$ ), you are using a law that isn't accurate. What you are doing is assuming an inaccurate law,  $a=a'$ . This law isn't true for relative velocities close to  $c$ . – Hide quoted text –

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Motion time is  $\Gamma$  and there is gravitational time slowing the metric.

Mitch Raemsch Twice Nobel Laureate 2008

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