Physics 210: Computational Physics
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Relativity for Dummies: Lorentz Transformations Made Easy

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Special Relativity is a one of the simpler theories in physics that still holds the fascination of the abstract qualities that make physics such an exciting subject. My project's intentions are to make these interesting concepts accessible to people who do not have much physics in their background. The two programs I have written will illustrate properties of Special Relativity without the user needing to do any actual calculations and can be used as a teaching tool/ work aid. The first program consists of a "Special Relativity Calculator." The calculator is written in c and will calculate transformed coordinates (using the Lorentz Transofmrations) for up to two events occuring in up to three inertial reference frames, one of them stationary and the others in relative motion to the first. The second program is an animation displaying of a rocket as it approaches the speed of light.

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I. SPECIAL RELATIVITY

Special Relativity is a theory in physics that was introduced by Albert Einstein in 1905. It refers to measurements made in inertial frames of reference. The two main postulates behind Special Relativity are: 1) All uniform motion is relative, there is no absolute state of rest and thus one is free to choose the axes to measure from; 2) All observers will always measure the same speed of light, no matter what their intertial frame of reference is [**?**]. An inertial reference frame is defined as a reference frame that is moving with a constant velocity, where Newton's laws of motion hold [**?**].

Special Relativity (SR) pertains to problems involving references frames moving at large speeds. Most problems involving SR concern rockets moving at fractions of the speed of light. The idea is that space and time distort when the intertial reference frame approaches the speed of light. These distortion are governed by what are called the Lorentz Transformations.

A. Lorentz Transformations

Special Relativity revolves around the basis of reference frames. A reference frame is a given set of axes in which one can refer to when making measurments of a specific event. The reference frames include axes of three dimensional space, but also time. One says that an event in 'space time' is an event that holds unique coordinates of space and time in a given reference frame.

If some event occurs in reference frame S it will have specific space-time coordinates in this reference frame x,y,z, & t. If there is another reference frame, S', in relative motion to frame S, then the event will appear quite differently in S' than it does in S. The event will hold different space-time coordinate in S' than it does in S, even though it is the same event occuring. The relationship between the event's coordinates in S and S' are given by the Lorentz Transformations:

$$t\prime = \gamma(t - vx/c^2) \quad (1)$$
$$x\prime = \gamma(x - vt) \quad (2)$$
$$y\prime = y \quad (3)$$
$$z\prime = z \quad (4)$$

where

$$\gamma = 1/sqrt(1 - v^2/c^2)\text{and}$$
$$\beta = \frac{v}{c} \quad (5)$$
$$(6)$$

`http://en.wikipedia.org/wiki/Special_relativity#Reference_frames.2C_coordinates_and_the_Lorentz_transformation`)

II. THE PROJECT

I have begun to design a program in c code that will hopefully allow for ease of use when performing Lorentz Transfomations. Thus far, I have accomplished in writing a c code that will give out the coordinates of an event in a moving reference frame given the initial coordinates and the veloctity of the reference frame in motion.

What I would like to do from there is create an animation of the event occuring. The purpose of this is because I believe it will drive the conept home to people who may not be able to understand why events may look different in different intertial reference frames. The idea is, then,

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that while the animation will not be to scale in any coordinate (velocity, time, etc.)it will still give the user an idea of what is going on, physically. Also, it seems to me that most users demand graphics these days because it appears more user friendly and since the whole point of this project is to make things as nice as possible for the user, I figure animation is necessary.

I could do this using c, but I think I would like to use something that has a much nicer graphics package than c. For example, I would like to do something more in 3 dimensions, rather than just the 1. As far as I know, c is very limited in dimensions.

I would also like to figure out a way to connect the given coordinates from the program and the animation. I would like the user interface to simply have an animation option, but not necessarily need the user to physically put in the new and old coordinates again. However, I do not know if this is even possible at my level, but I figure aim high while I still have the ambition.