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How many postulates is Special Relativity based upon ?

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As was pointed out in "The principle of not exceeding", studying the works of prominent scientists and engineers is a must for both learning problem solving skills and finding new important problems. I will show how study of the primary sources makes a difference on the convenient example of Special Relativity.

In my student years in the 1970s I read several university texts on special relativity. I could not read the original work of Einstein as it was not easily accessible. The internet has not been invented yet and it was impossible to download "On the electrodynamics of moving bodies" from it.

All these texts stated that Special Relativity is based on 2 postulates: the constancy of the speed of light in any inertial frame of reference and the principle of relativity. They taught that from the postulate of constancy of the speed of light it follows that inertial frames of reference moving relative each other do not have common time. It was usually illustrated by a mental experiment with the ray of light emitted from the center of a moving rod in both directions. While the light reaches the ends of the rod simultaneously in the frame of reference relative to which the rod is at rest, it does not reach the ends simultaneously in the frame of reference relative to which the rod is moving. From here the texts proceeded to deriving the Lorentz transformations between space-time coordinates of frames of reference moving relative to each other. Etc.

What "simultaneously" meant was not discussed in these texts. It was assumed to be self-evident. But this is not how Einstein started his theory. Simultaneity of events is only self-evident for co-located events, he said. But for events separated in space simultaneity has to be defined. Einstein defined it through synchronicity of clocks co-located with events. If a clock co-located with event X is synchronous with a clock co-located with event Y and both clocks show the same time when the events occur, then they are simultaneous. This definition was obviously dependent on definition of synchronicity of clocks located at different points in space. And Einstein proceeded with defining it too. According to him, clocks located at points A and B respectively are synchronous if

$$T_B - T_A = T'_A - T_B \quad (1),$$

where T_A is the time on the clock located at point A when light was emitted from this point towards point B, T_B is the time on the clock located at point B when the light reached it and was reflected back by a mirror, and T'_A is the time on the clock located at point A when the light returned to it.

> Einstein did not explain his definition in the paper but it is not difficult to understand it. Suppose light leaves point A at 9:00am. Suppose it takes 1 min for the light to travel from point A to point B. (Strictly speaking this assertion is not verifiable until synchronicity is defined and clocks are synchronized.) Thus, to say that it takes 1 min for the light to travel from A to B we have to assume that clock at B shows 9:01am when light arrives. If clock at A shows 9:02am when light returns back then indeed it takes 1 min for light to travel between A and B and clocks are indeed synchronous. In this case T_A = 9:00am, T_B = 9:01am, and T'_A = 9:02am and relationship (1) holds. But suppose that clock at B shows 9:05 when light arrives, and clock at A shows 9:02 am when it returns back. Then either speed of light in direction from A to B is different from the speed of light in direction from B to A, or the clocks are not synchronous. Since the former is excluded due to the isotropy of space, we conclude that clocks are not synchronous, and $T_B - T_A \neq T'_A - T_B$.

Einstein used this definition of synchronicity of clocks separated in space to derive the Lorentz transformations. All texts that I studied did it differently without resorting to the definition.

> (By the way, Einstein employed a mathematical trick, or invention if you will, to make the derivation simple. The trick was apparently invented by him after accomplishing a direct derivation to simplify it. He omitted the direct but more complex derivation in his paper. I restore it in a separate article.)

Since the texts did not use the definition of clocks synchronicity to derive the Lorentz transformations they missed the whole bunch of important and interesting issues. For instance, Einstein defined how to judge whether clocks are synchronous or not but has not proposed how to synchronize them. Meanwhile, absolute synchronization is impossible.

Indeed, suppose synchronization is done in the following way. An observer at point A at 9:00am raises the card with number 9 on it. Observer at point B sees the number 9 and sets his clock to show 9:00am too. Do the clocks get synchronized in such a way ? Not at all. Firstly, there is a delay between the moment when the observer at A raises number 9 and the moment when the observer at B sees it. This delay is the time required for light to travel from A to B. Secondly, setting the clock after the observer saw the number also takes time. Even if he knows the distance between A and B and thereby knows the time light takes to travel he does not know in advance how long will it take to set the clock, as this time is random. Even if he has a second clock that measures how long it took to set the clock the first time, turning clock back by twice this amount would not make the clock at B synchronous with the clock at A as time required to set the clock the second time may differ from the time it took to set it the first time.

The same problems emerge with any other way of synchronization of clocks. Thus, absolute synchronization is impossible. There is even a limit to which clocks could be synchronized. And this limit is determined by the very speed of light. Execution of any operation by any circuit cannot be done faster than the time required for the signal to travel the entire circuit.

It might appear that the discrepancy in synchronization is negligible as it is just a fraction of a second. That would be the case if the time required for light to travel from A to B were much longer. But if it is also a fraction of a second (as is the case for all points on our planet) then relationship (1) does not hold just because of the tiny discrepancy in synchronization.

Thus, we arrive at the conclusion that the assumption of the existence of common time for all points in the same inertial frame of reference, is nothing else but a third postulate of special relativity, a tacit though.

Here is how study of primary sources, i.e. the very works of the great scientists and engineers, brings about new food for thought and points to new problems.

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