Rethinking Time Dilation: Unveiling the Nuances of Special Relativity Through Clock Placement

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Abstract: ***This article points out the mistake in a Time dilation calculation in the special theory of relativity by explaining difference between time value in relation to origin of the primed reference frame compared to time value in relation to point P where clock is placed. It is explained in the article that for the two different situation A and B there are difference in the time dilation equations. Equation in the situation A is not a general form, while equation in the situation B can be considered as a general form. Here situation A is a situation when clock is placed on the origin of the cartesian plane attached to S' frame and situation B is the situation when clock is placed at some point randomly selected toward positive X axis of the S' frame. The equation of time dilation in general situation is the correct and whole expression of time dilation and not the restricted equation for the situation A. This general equation for the time dilation shows dependency on the direction of the velocity "v", So, that will also show time contraction instead of time dilation when S' will move toward negative X axis in Situation B. So, this not only shows a mistake in calculation of the time dilation, but this just refute the special relativity theory by showing time contraction!***

Keywords: Time dilation, time contraction, Lorentz transformation, Special theory of Relativity, Special Relativity.

1. Introduction

In the special theory of Relativity proposed by albert einstein, consequences of the postulates of the special theory of relativity leads to time dilation when two inertial reference frames move with uniform rectilinear velocity with reference to each other and clock is placed in one reference frame. That relative time dilation occurs irrespective of the direction of the motion of the primed inertial reference frame. The erroneous logic used while calculating Time dilation is shown in this article and correction is suggested.

Article

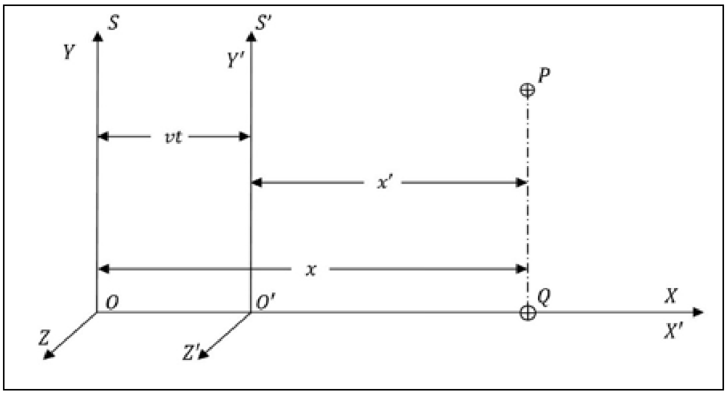

Figure 1

Cartesian planes are attached to S and S′ inertial reference frames.

S′ inertial reference frame is moving with uniform rectilinear velocity "v" along with positive X axis.

Point P is chosen randomly on the side of positive X axis in a stationary reference frame S, Co-ordinates of the P in the S frame is (x, y, z, t) and co-ordinates of the point P in the S′ frame is (x', y', z', t')

Q is a point on the positive X axis with co-ordinates (x, 0, 0, t)

Let's derive corrected time dilation first.

Now,

Deriving Corrected Time dilation using Lorentz transformation equations.

Lorentz transformation equations for distance or t co-ordinates of the object is,

$$t' = \frac{t - \frac{xv}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Now time dilation Δt will be,

$$\Delta t = t - t'$$

$$= t - \frac{t - \frac{xv}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$= t - \frac{t - \frac{ctv}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$= t - \frac{t - \frac{tv}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\Delta t = t\left(1 - \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}\right) \quad where\ v < c$$

Above equation shows the corrected value of time dilation.

Now let's see what's given in A book, "Relativity, The special and The General theory by Albert einstein, 1916"

"Let us now consider a seconds-clock which is permanently situated at the origin ($x' = 0$) of K'. and $t' = 0$ and $t' = 1$ are two successive ticks of this clock. The first and fourth equations of the Lorentz transformation give for these two ticks:

$$t = 0$$

And

$$t = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

As judged from K, the clock is moving with the velocity v; as judged from this reference-body, the time which elapses between two strokes of the clock is not one second, but $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ seconds, i.e. a somewhat larger time. As a consequence of its motion the clock goes more slowly than when at rest. Here also the velocity c plays the part of an unattainable limiting velocity."

So, as per the descriptions above,

$$\Delta t = t_1 - t_0$$

$$= \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 0 = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\Delta t = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad where\ v < c.$$

Now let's understand this,
For $t' = 0$, $x' = 0$
For $t' = 1$, $x' = 0$.
Let's understand with figure below.

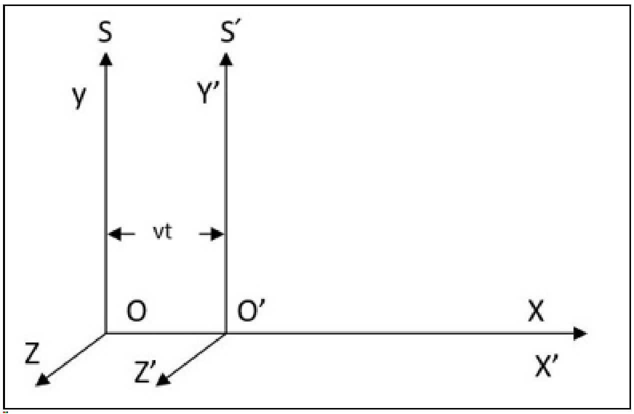

Figure 2

Here,
vt is the distance between origin O of the S frame and clock is placed at O′ in the primed reference frame S′.
at $t = 0$,

$$OO' = 0,$$

That will give $t' = 0$.
But when
$t = 1$,
Then $x = 0$, but vt≠0, because S′ moves with velocity v.
So here,

$$t' = \frac{t - \frac{xv}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1 - \frac{(0)(v)}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t' = \frac{1 - 0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t' = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

So,

$$\Delta t = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

This value of time dilation is valid for the clock placed at the origin of one reference frame only.

Now let's see what happen when we place clock at $x \neq 0$, place.

So, for that situation figure will be figure-1 again.

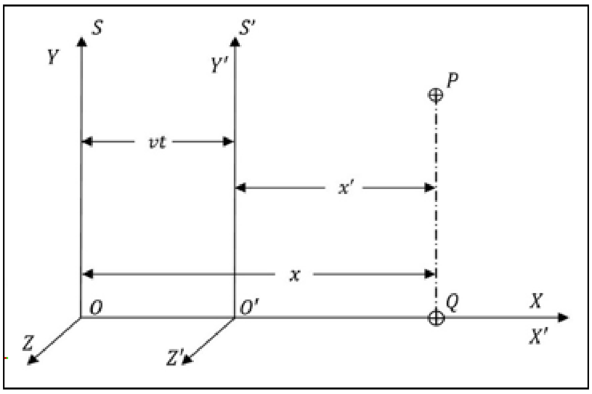

Figure 1

Here, Clock is placed on P.

vt is the distance between origin O of the S frame and O′ in the primed reference frame S′.

S′ moves only along the positive X axis of the non-primed S reference frame with uniform rectilinear velocity, so y and z co-ordinates of the P will not get changed and only x co-ordinate will change. So, we can replace change in the x co-ordinate of P by that of Q. So, we will use Q for calculations for x co-ordinate of P.

at t=0, vt_o=0 but $ct_q \neq 0$, here $t_o$is a time related to O′ and t_q is the time related to Q.

So, here, there must be,

$$t_q = t_o + \frac{x_q}{c}$$

$where\ x_q\ is\ the\ ct_q, a\ distance\ between\ O\ and\ Q)$

If we put value of t_o=0, then we will get,

$$t_q = \frac{x_q}{c} = \frac{ct_q}{c} = t_q$$

This suggest that t value for two different point with different x co-ordinate value must be different.

Here t_o is the time for a photon to travel from O′ to O.
and t_q is the time for a photon to travel from Q to O.

at time zero, origin of both reference frame will co-insides, So, $OO' = t_o = 0$, this is because there is a no physical distance between O and O′ at a time t equal to zero.

But x co-ordinate of the P or Q is not equal to zero in S frame even at the time equal to zero.
That x co-ordinate will be equal to ct_q at a time equal to zero and it is the physical distance of Q from the origin O measured with light at a speed c.

So, here
$OQ = O'Q \neq 0$ & $x_q = ct_q \neq 0$,
But $vt_o = 0$

That will give,

$$t_q{}' = \frac{t_q - \frac{x_q v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_q{}' = \frac{t_q - \frac{ct_q v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_q{}' = \frac{t_q - \frac{t_q v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_q{}' = t_q \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\neq t_q \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

And

$$\Delta t_q = t_q - t_q{}'$$

So,

$$\Delta t_q = t_q \left(1 - \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}\right)$$

$$\neq \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

This value of time dilation is valid for the clock not placed at the origin of one reference frame but placed at point with x co-ordinate value, where $x \neq 0$.

In further-more general type of calculations where t=0 is not taken in the calculations,

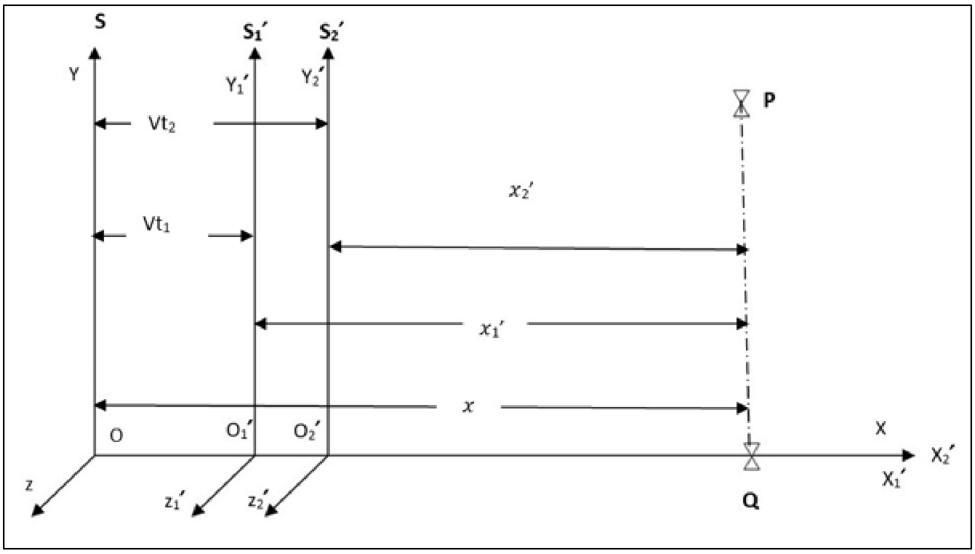

Figure 3

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Here S′ is a primed or moving reference frame. S is non primed or stationary reference frame.

P is the clock placed at the point P and Q is the analogues clock at point Q with same x co-ordinate value of P and it is on the positive X axis. S′ frame moves with the uniform rectilinear velocity v along the positive X axis, at the time t_1 the origin of the S′ reference frame reach at a distance vt_1 and that is shown as S_1'. At the time t_2 the origin of the S′ reference frame reach at a distance vt_2 and that is shown as S_2'. x Co-ordinates of P are shown as distance between P and respected reference frames.

Here,

If we apply equation,

$$t' = \frac{t - \frac{xv}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Then

$$\Delta t' = t_1' - t_2'$$

$$= \frac{t_1 - \frac{x_1 v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} - \frac{t_2 - \frac{x_2 v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Here, you can see in the figure that,

For the different time t_1 and t_2, there will be a different ct_1 and ct_2, so there will be a different x_1 and x_2.
And $vt_1 \neq vt_2$ for two different t.

Means time measurement can’t be measured in a moving reference frame at same location or same distance. Means you can’t choose same place for S_1' and S_2', for $t_1 \neq t_2$. So, we can’t cancel out $\frac{x_1 v}{c^2}$ with $\frac{x_2 v}{c^2}$.

Now, let’s move further,

$$\Delta t' = \frac{t_1 - \frac{x_1 v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} - \frac{t_2 - \frac{x_2 v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\Delta t' = \frac{t_1 - \frac{ct_1 v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} - \frac{t_2 - \frac{ct_2 v}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$= \frac{t_1\left(1 - \frac{v}{c}\right)}{\sqrt{1 - \frac{v^2}{c^2}}} - \frac{t_2\left(1 - \frac{v}{c}\right)}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$= \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}(t_1 - t_2)$$

$$\Delta t' = \Delta t \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\neq \Delta t \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

If we put cartesian plane in a manner that origin of S_1' can be placed at (0,0). Then Δt will be t, and $\Delta t'$ will become t′. in that case,

Time dilation ΔT will be,

$$\Delta T = t\left(1 - \frac{1 - \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}\right)$$

$$\neq \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

2. Conclusion

There is a mistake in the calculation of time dilation given in the quoted first in the references, that calculation can be applicable to the clock placed on the origin of one of the two reference frame only. When we place clock at different place other than origin of the reference frame, we would find different equation for time dilation which is dependent on the value of v and that is capable of showing time contraction also. As the concept of time contraction enters in the framework of special theory of relativity, its structure collapses and time doesn’t stay as a fourth dimension.

So, there must be a re-evaluation of the calculation of time dilation and foundation of the special theory of relativity.

Similar mistakes should also be corrected in the calculation of the length contraction.

References

[1] A book, “Relativity, The special and The General theory by Albert einstein, 1916”
[2] A book “RELATIVITY REFUTED” by Dr. Hasmukh Devidas Rathod “2024”. isbn 9789334028751 or isbn 97988991701007.