PROLOGUE

What is well accepted in theoretical physics is that when a clock A is moving at a velocity v across a frame of reference K and further assuming that frame K had a set of spatially separated and acceptably "synchronized" clocks, then the moving clock A appears to be running slow, as seen by the "synchronized" clocks in K. Since clock A is moving across frame K, its time cannot be measured by a single clock in frame K, and therefore, there is a necessity for having a set of spatially separated and synchronized clocks in frame K to monitor the running of the moving clock A.

Clock A O → v

O	O	O	O	O	O	O	O	O	**Frame K**
K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	

To restate the basics, clocks K1, K2, K3…are stationary clocks in frame K; they are synchronized within the frame K by some "acceptable" method. Clock A is moving with respect to the frame K at velocity v. It is observed by the clocks on frame K that clock A is slowing down as it moves along frame K. For example clock A and clock K1 may be showing the same time as A passed K1 but when A passed K9, clock A was showing a time less than that shown by K9. Since K1 and K9 are synchronized within frame K, it can be concluded that clock A is running slower compared to clocks in frame K.

Now let us consider two frames K and K′ moving with respect to each other at a velocity v. There are clocks on K as before K1, K2, K3, K4… which are synchronized within frame K. Similarly, K′ has clocks which are spatially separated and synchronized and named K1′, K2′, K3′, K4′….

O	O	O	O	O	O	O	O	O	**Frame K' → v**
K1'	**K2'**	**K3'**	**K4'**	**K5'**	**K6'**	**K7'**	**K8'**	**K9'**	

O	O	O	O	O	O	O	O	O	**Frame K**
K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	

Now theoretical physics states that each clock K1′, K2′, K3′, K4′…slow down as seen by the clocks in K. This is natural because each clock in K′ can be considered as clock A of the previous paragraph. But the tricky part is that each clock in frame K, i.e. K1, K2, K3, K4.., , also slow down as seen by the clocks in the frame K′ by virtue of symmetry which theoretical physics demands of the situation.

This topic was a developing matter in the end of 19th and the beginning of 20th century. A mathematical formulation consistent with the physical description as above in which clocks in both frames K and K′ slow down as seen by clocks in frames K′ and K was developed by scientists and mathematicians starting with Fitzgerald & Lorentz . These equations were later interpreted by Poincare, Minkowski & Einstein.

It appears that the mathematical formulation which is known as Lorentz transformations can have two widely different physical interpretation. The following article describes both the viewpoints in a succinct way.

Title: Special Relativity Made Easy

By
Chandra Mouli Iyer*

Abstract: The Lorentzian interpretation of the slowing down of moving clocks is that it is an actual slow down. This immediately necessitates the existence of an absolute rest frame. The Einstenian interpretation is that it is an apparent slow down due to a rotation in a space-time continuum. The later

interpretation maintains the equivalence of the two moving frames and eliminates the need for an absolute rest frame. However, it creates other issues; these are the future in one frame being the present (or past) in another frame. The following is an elegant and simple derivation of the Lorentzian version. All observable physical events obey the same formulae under both the interpretations and hence proving or disproving either one against the other is virtually impossible. In this scenario the universal acceptance of the later version is somewhat unwarranted.

Special Relativity Made Easy

By

Chandra Mouli Iyer[*]

The version in which clocks actually slow down while moving and yet all the equations of the Einstenian Relativity remain intact.

1. Assume that a stationary Isotropic (all directions are equivalent) reference frame exists. Let us call this frame K .

2. Absolute velocity of any moving object or clock is measured w.r.to K .

3. Assume that any clock moving at an absolute velocity of v will run slow by a factor f(v).

4. Within frame *K*, there is a set of synchronized clocks at origin x=0. We wish to separate them to different spatial locations x1,x2,x3, ….. etc. In general a particular clock is moved slowly to a location x at a velocity v and then it is left at location x. In this process, the time taken will be (x/v) in frame *K*, while the clock that is being moved will show an elapsed time of (x/v) f(v).

5. Hence, after reaching location x, the clock would have developed an asynchronicity of (x/v) (f(v)-1)

6. Evidently when v=0, f(v) = 1. Therefore we can rewrite the asynchronicity as (x/v) (f(v)-f(0))

7. If we separate the clock very slowly and taking this proposition to the mathematical limit, we can let v $\rightarrow$ 0 and then we get the asynchronicity to be x f ' (0)

8. Since frame K is isotropic, for the function f(v), f(+v) = f(-v) or f(v) is an even function and therefore f ' (0) = 0 and hence the asynchronicity x f ' (0) = 0.

9. Therefore the method of separating clocks slowly, yields a set of spatially separated yet synchronized clocks in an isotropic stationary frame.

10. Now consider a moving frame *M*, moving with a velocity *V* with respect to *K*.

11. Further consider that an observer in *M* assumes that *M* is stationary and isotropic and applies the same method for

synchronizing spatially separated clocks as by an observer in *K*.

12. He separates two clocks by a distance x, by moving one of them at a velocity v. But since the frame *M* is already moving at *V*, the absolute velocity of the moving clock will be *V*+v. The time taken for the separation will be x/v as seen by *K*, (x/v) f(*V*) as seen by the clock at x=0 in *M* and (x/v) f(*V*+v) as per the clock that is being separated.

13. At the end of the separation the asynchronicity developed between the two clocks in *M*, the one at x=0 and the one at x will be [(x/v) f(*V*+v)] - [(x/v) f(*V*)]

14. Setting the limit as v $\rightarrow$ 0 in the same manner as before, we get the asynchronicity to be x f ' (*V*).

15. In general this asynchronization is zero only when *V*=0 (i.e for frame *K*). However *M* believes that his spatially separated clocks are synchronous because he believes that his frame *M* is stationary and isotropic.

16. Now consider the frames *K* and *M* aligned as below at t=0. All clocks in frame *K* show t=0 as they are truly synchronous. But clocks in frame *M* show times as below due to the asynchronicity in frame *M* as discussed above.

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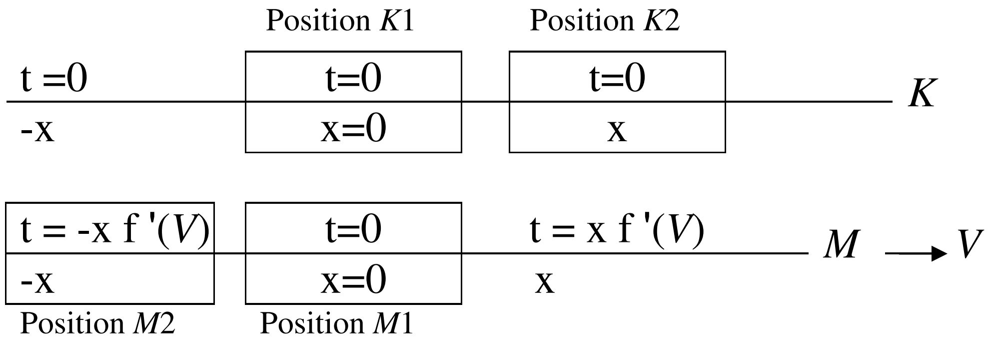
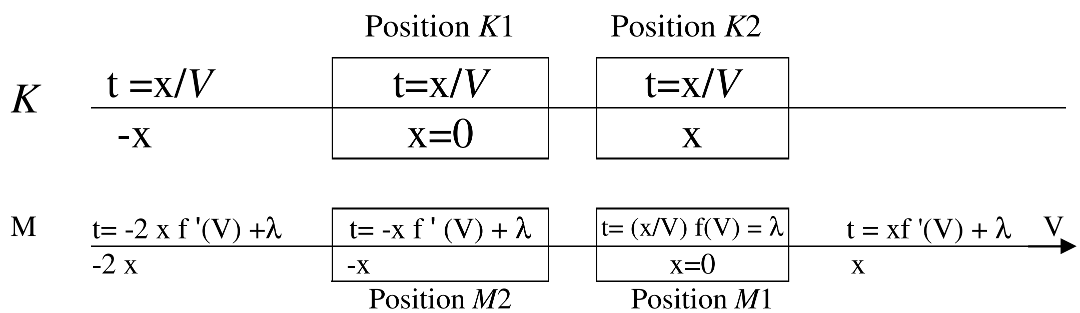


17. Since frame M is moving at velocity V, the picture as above will change to the one as below after a lapse of time (x / V)



Note: Where $\lambda = (x/V)\, f(V)$

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18. If we impose the condition that M and K shall see each other in a "symmetric" way, then we require

$$\frac{\text{Time at } K1}{\text{Time at } M2} = \frac{\text{Time at } M1}{\text{Time at } K2}$$

19. In other words

$$(x/V) / [-x f'(V) + (x/V) f(V)] = (x/V) f(V) / (x/V)$$

Or $1 / [-V f'(V) + f(V)] = f(V)$

20. Solving the above differential equation by separation of variables, we get two solutions

$f(v) = (1-k^2v^2)^{½}$ ----------- (1) when $f(v) \leq 1$

and $f(v) = (1+k^2v^2)^{½}$ ----------- (2) when $f(v) \geq 1$

depending on whether we choose $f(v) \leq 1$ or $f(v) \geq 1$ while separating the variables and rearranging the differential equation.

21. For the moment we ignore the solution where $f(v) \geq 1$ and select the solution $f(v) = (1-k^2v^2)^{½}$ as this alone will lead to the apparent constancy of the velocity of light.

22. Therefore, if moving clocks slow down as per the function $f(v) = (1-k^2v^2)^{½}$, then the view point from *K* and *M* will be symmetric in that both will see each others clocks slowing down.

Summary

a) A stationary frame can develop a system of spatially separated yet synchronized clocks by separating these clocks at slow velocities.

b) A moving frame, when it adopts the same procedure for synchronization of clocks, will in actuality develop a system of asynchronized clocks.

c) The moving frame will assume that such a set of asynchronized clocks to be synchronous.

d) When the slowing down of moving clocks is determined by the function **$f(v) = (1-k^2v^2)^{1/2}$,** the view points from both the moving and the stationary frame will be symmetric in that both will see each others clock slowing down. This symmetry is achieved by the combination of the asynchronicity and the slowing down of clocks.'