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TIME DILATION

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Abstract:-

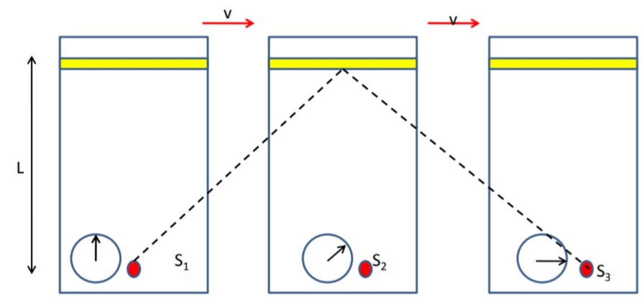
This article is about relativistic time dilation as proposed by Albert Einstein in his special theory of relativity.

We humans are pretty intuitive about time. We like to believe whenever and wherever we are time is always constant for everyone of us. But I still showed this is not the case. Time is relative depending upon the frame of reference of the observer. This phenomenon is called time dilation.

Relative velocity time dilation:-

Consider a frame F on which there is a mirror and a source of light S. There is a distance l from the source of light S and the clock. Let there be three events A, B and C. The event A is the light produced by the source is leaving the source, the event B is the light getting reflected by the mirror and the events being the reflected light returning to the source point S. The time interval between event A and C, measured by the clock at that frame is Δt= 2L/c, c is the speed of light and 2L is the distance traveled by the light in frame F.

Now, imagine that the frame F is traveling to the right of you with a velocity v, and you are stationary at your frame and you are watching the three events happening and noting the time with clocks in your frame. During the time, Δt' the events A and C occurs, the F has also moved a distance to vΔt'. The length traveled by light, as seen by you, will not be 2L as previous case, but we need to consider vΔt' using Pythagoras theorem. Refer the picture below.



So, here after a small calculation, we get,

$$\Delta t' = \frac{\frac{2L}{c}}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$$

Or,

$$\Delta\tau \equiv \Delta t\,(\text{proper}) = \Delta t'(\text{Improper})\sqrt{1-\left(\frac{v}{c}\right)^2}$$

Point to be noted, in the first case, the starting and ending event was measured by the same clock, as both the events were taking place at the same place. The time taken by that clock is called proper time. But in the second case, the starting and ending event wasn't at the same place in our frame, as it was moving w.r.t to us, so we need TWO CLOCKS placed at those space points to measure the events. The time interval recorded is improper time. This can't be measured by a same clock as for that case, we need to travel along with the frame F. That will make us in the frame F itself and will be similar to first case.

Discussion:-

- Clocks that are perfectly synchronized in one frame, may not look synchronized,

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on observing from any other frame from any other frame.

- And, a moving clock runs slow. This means, time interval recorded by clock in a frame moving wrt us is less than by clocks in our frame. It may be 2 hours inside a plane, but to us on earth, it may be 2.15 hours. Of course the speed of the plane need to be close to the speed of light to see any actual effect.

Now, which of the observer is true, or which time interval is the correct one, this question may arise. The answer is nothing wrong, every observer is correct in their own frame. There is nothing absolute value, everything is relative.

Reference:-

Wikipedia
Modern physics- A.B GUPTA