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7 Einstein's postulates (Special Theory of Relativity)

1. All Laws of physics including Maxwell's Theory of Electromagnetism holds good in all inertial frames of reference. This is an extension of principle of Relativity

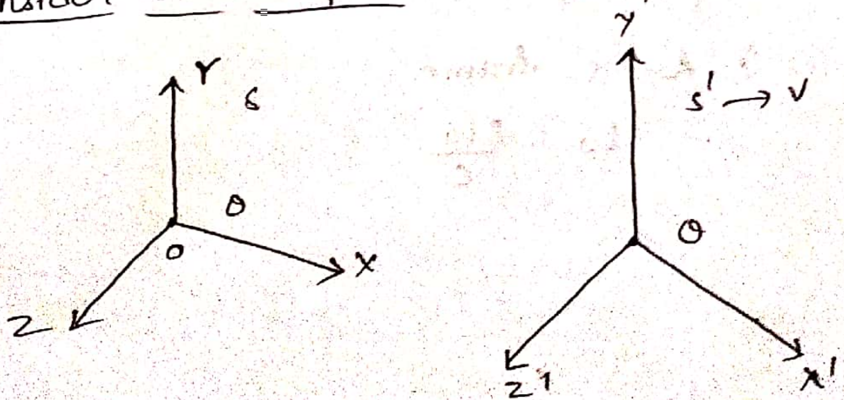
2. The speed of light in vaccum has the same value in all inertial frames of reference independent of the speed of the observer or that of the source emitting the light

10. Time Dilation :- A clock in a moving frame of reference measures a longer time interval between two events while for the same event the clock in the stationary frames measures short time interval.

$$t = \frac{t_0}{\sqrt{1-v^2/c^2}} = \frac{t_0}{\sqrt{1-\beta}} = \gamma t_0$$

$$\boxed{t = \gamma t_0} \qquad \beta = \frac{v^2}{c^2} \qquad \gamma = \frac{1}{\sqrt{1-\beta}}$$

Consider an example

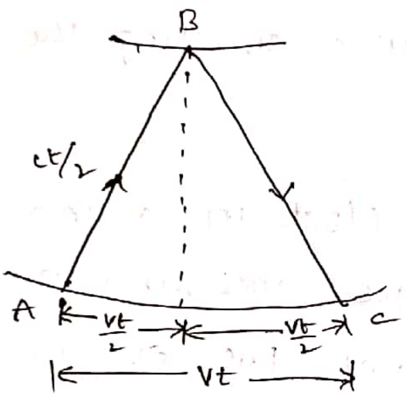


s' is moving with velocity v' relative to s

The person in s' observes that the time difference b/w two events is 10sec. The same two events when observed by a persom from s frame feels that time difference b/w two events is 15sec.

The difference in time is called

Time Dilation



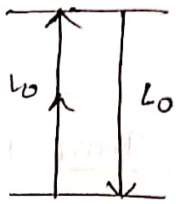


fig 1

Derivation :-

consider that a person in frame s' throws ball up to a distance of L_0 then the time taken to reach the point of throw is shown in fig 1

Total distance travelled is $L_0 + L_0 = 2L_0$

velocity = c

$\therefore$ for s' frame

$$t_0 = \frac{2L_0}{c}$$

Event observed from S frame

Now the same event when observed from the frame S the person feels that the distance travelled by the ball to go up and down is time t

The person feels that the ball has travelled from A to B and from B to C.

The total time taken is t

So distance from A to B is $\frac{ct}{2}$

Apply pythagorous theorem

$$\left(\frac{ct}{2}\right)^2 = \left(\frac{vt}{2}\right)^2 + L_0^2$$

$$\frac{c^2t^2}{4} = \frac{v^2t^2}{4} + L_0^2$$

$$\frac{t^2}{4}(c^2 - v^2) = L_0^2$$

$$t^2 = \frac{4L_0^2}{c^2 - v^2} = \frac{4L_0^2}{\left(1 - \frac{v^2}{c^2}\right)c^2}$$

$$t = \frac{2L_0}{c\sqrt{1 - \frac{v^2}{c^2}}} = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t = \frac{t_0}{\sqrt{1-\beta}} \quad \text{where } \beta = \frac{v^2}{c^2}$$

$$\boxed{t = \gamma t_0} \quad \text{where } \gamma = \frac{1}{\sqrt{1-\beta}}$$

$v << c$ so $\beta < 1$ then $\gamma > 1$

then $t > t_0$