Relativity

Relativity involves measurements, events, and reference frames.

An example of the use of refrence frames was used in an earlier kinematics chapter.

Ex Determine the speed of a toy car that moves at a constant 0.2 m/s in a bus moving at a constant 25 m/s as measured by an observer on the ground.

$$V_{Tg} = V_{Tb} + V_{bg}$$

V_{Tg}: Velocity of toy with respect to ground

V_{Tb}: Velocity of Toy with respect to bus

V_{bg}: velocity of bus with respect to ground

In the refrence frame of the bus the toy moves at 0.2 m/s because the bus is at resd in this frame.

In the reference frame of the ground the toy moves at 25.2 m/s because both bus and toy are moving in the ground reference frame.

This example shows how relative velocities are calculated classically.

According to this classical treatment time is the same in all reference frames.

An event that takes 10s in frame A will also take 10s in frame B, or any other frame you may choose.

Relativity rejects this assertion.

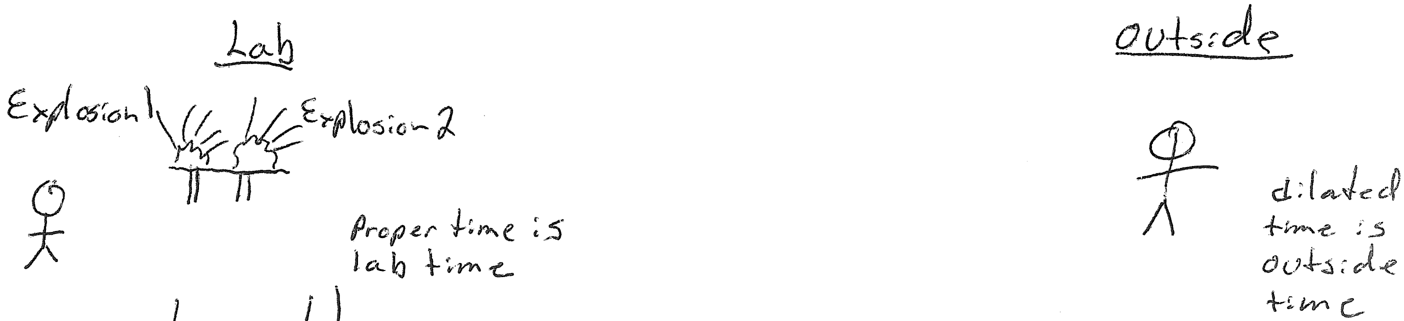
Postulates of Relativity (Special Relativity)

1. The laws of physics are the same for observers in all inertial frames.

2. the speed of light is c in vacuum in all directions in all inertial frames.

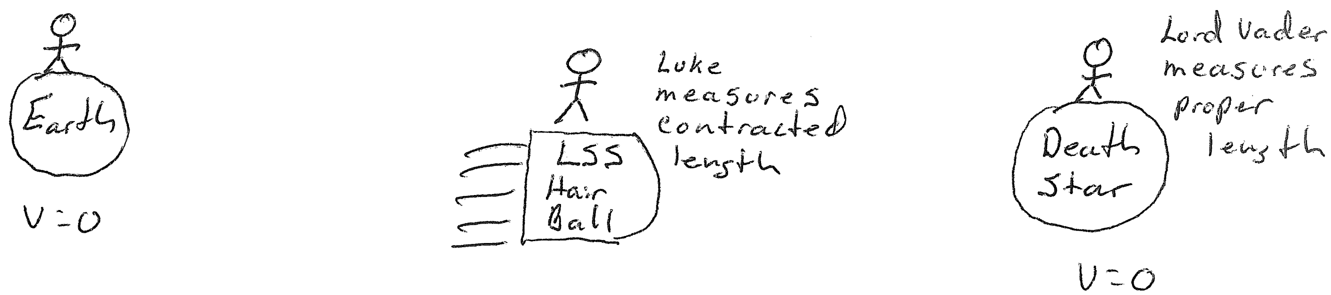
Proper Time

Time separating two events at the <u>same</u> <u>location</u>.



Proper Length

Distance between two points as measured by an observer at rest relative to them.



Event

Anything that happens at a specified place and time.

Time Dilation

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

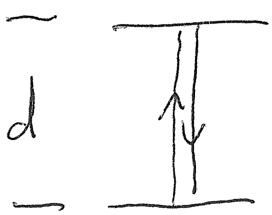
Δt = dilated time (s)

Δt_0 = proper time (s)

v = observer velocity (m/s)

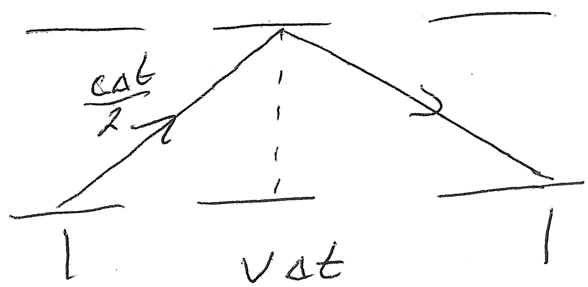
c = light speed in vacoom.

Clock At rest



$$2d = c\Delta t_0$$

moving clock



$$d^2 + \left(\frac{v\Delta t}{2}\right)^2 = \left(\frac{c\Delta t}{2}\right)^2$$

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

$$d^2 = \frac{c^2 - v^2}{4}\Delta t^2$$

$$\frac{4d^2}{c^2 - v^2} = \Delta t$$

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

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

Binomial Expansion

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{v^2}{c^2}}} \approx \Delta t_0 \left(1 + \frac{1}{2}\frac{v^2}{c^2}\right)$$

* use this when the calculator does not show enough digits.

Time Dilation affects the time between events and the progress of time for an observer.

Length Contraction

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

L_0 = proper length (m)

L = contracted length (m)

v = observer velocity (m/s)

c = speed of light in vacuum.

* only affects lengths in the direction of motion

Length Contraction occurs due to different time measurements recorded by observers in relative motion.

Since all observers measure light velocity as c in vacuum and $c = \frac{\Delta L}{\Delta t}$ each observer must measure both different L and t values.