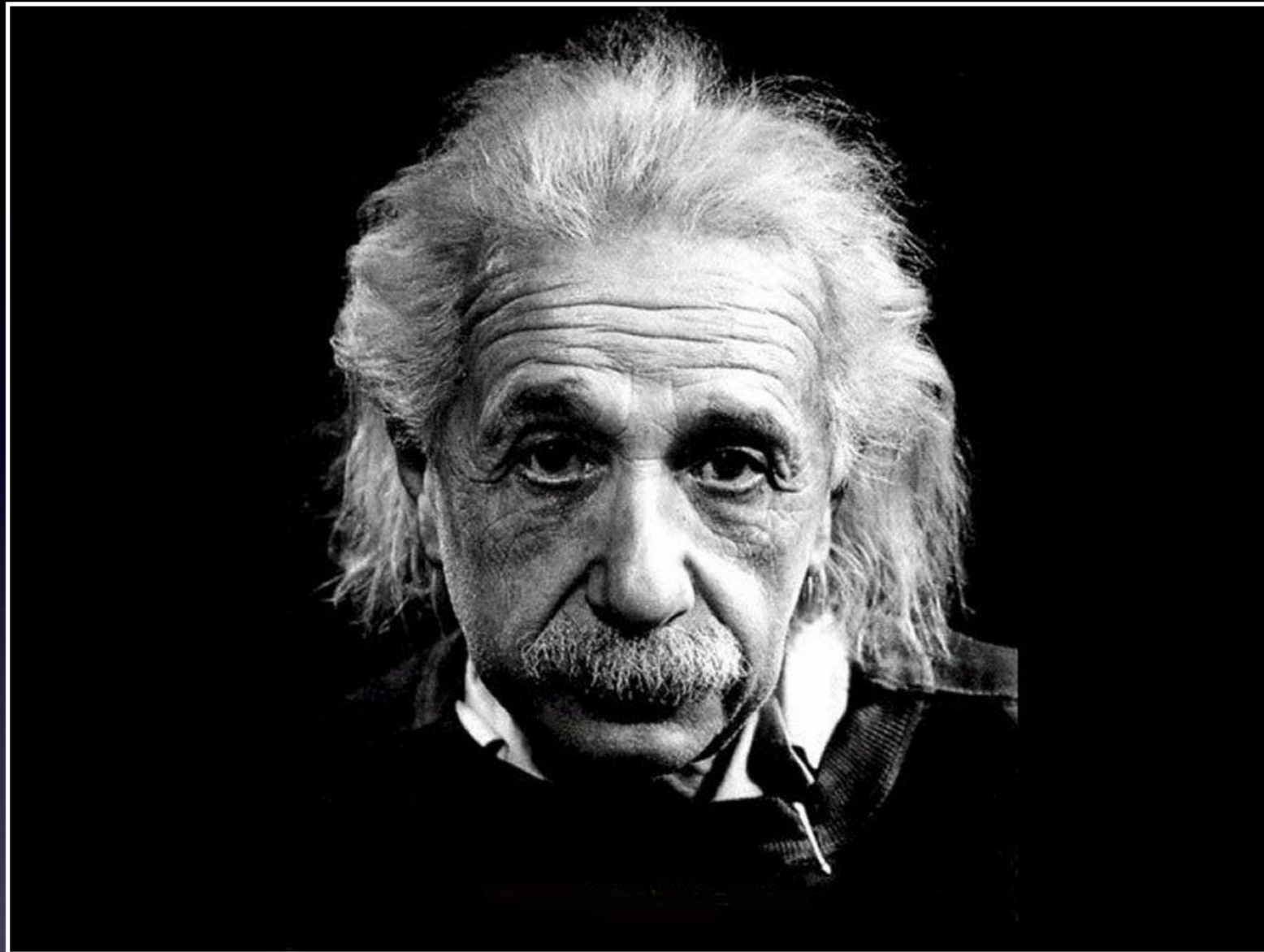


Special Relativity

Jason Polomchak



$$E = mc^2$$

Albert Einstein

- Wrote several papers in 1905 while working as a patent clerk.
- First introduced special relativity in his paper on the electrodynamics of moving bodies.
- $E=mc^2$ in his paper on mass-energy equivalence.
- Work was controversial or simply ignored, but was finally accepted by Max Planck.
- Nobel Prize in Physics in 1921

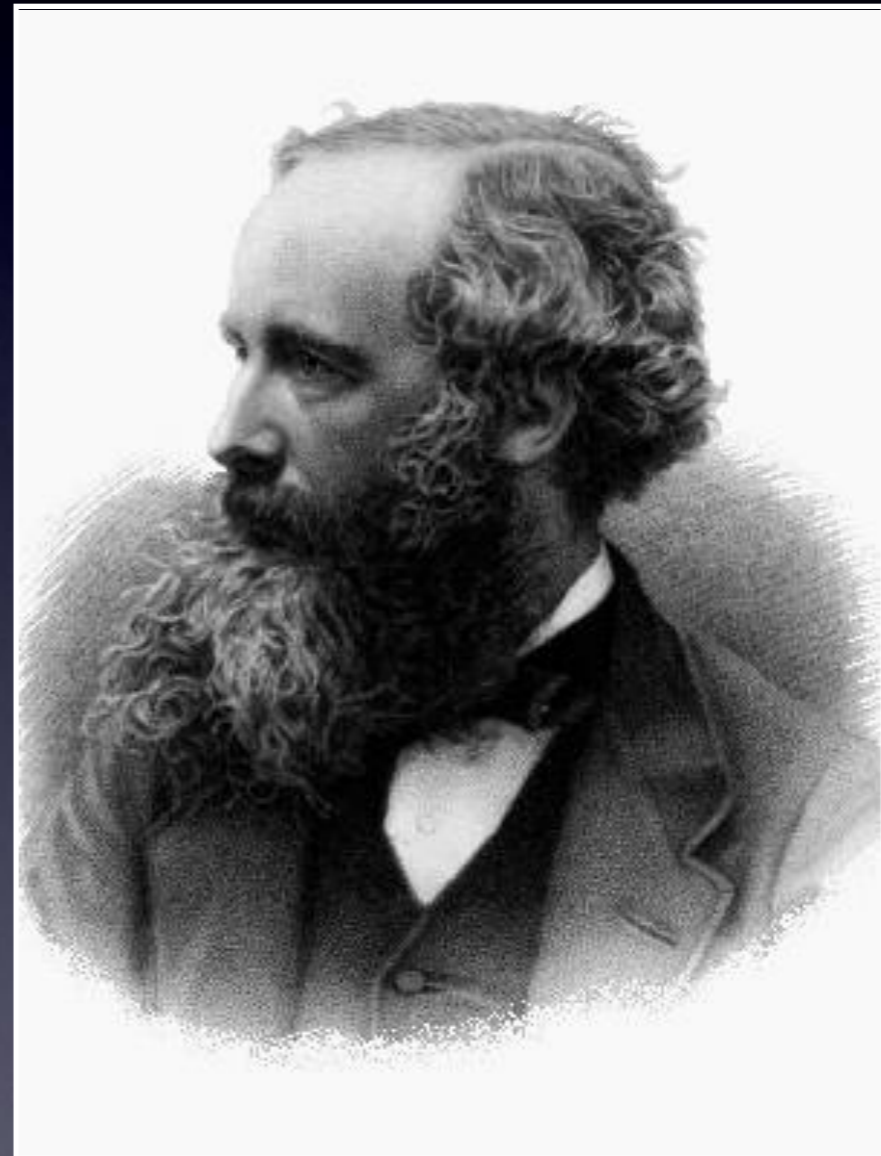


Classical Relativity

- A method for two observers to agree on what they see if one of them is moving.
- How fast am I moving? Relative to What?
- Reference Frame - Where an observer happens to be “standing.”
- Inertial Reference Frame - Non-Accelerated.
- Add and subtract velocities. (No absolute velocities)
- No internal experiment that can distinguish between a system that is moving in a line at constant speed and one that is at rest.
- Galileo’s ship experiment.

James Maxwell

- Unified electricity and magnetism into four equations.
- Electromagnetic wave that would travel through empty space at exactly the speed of light.
- Light is an electromagnetic wave that travels at about 186,000 mi/s.
- Relative to what? The equations suggest everything.



Relativity/Maxwell

- Who's Right?
- Maxwell says that light travels at a constant speed of 186,000 mi/s, always.
- Classical Relativity says there are no absolute velocities.
- Could both be correct?

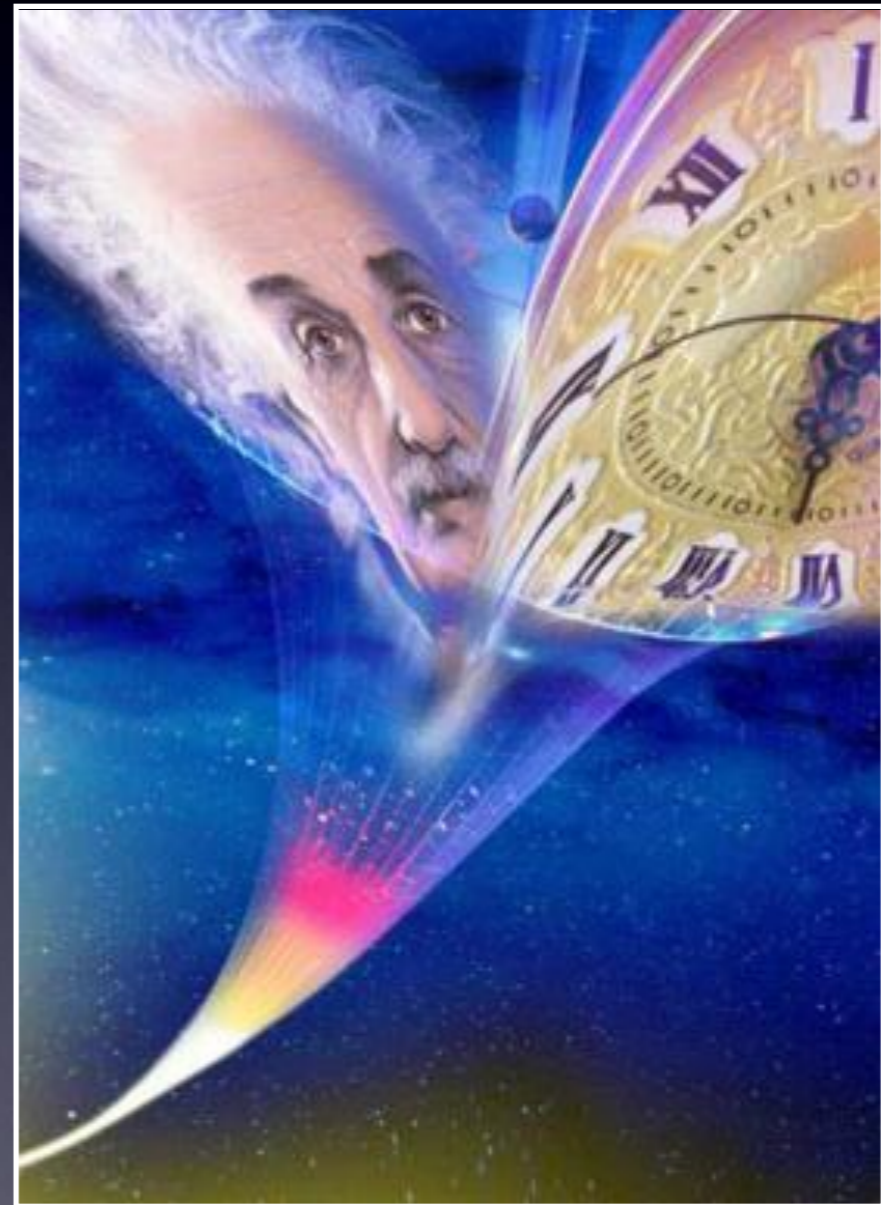
Postulates of a Patent Clerk

- 1. The laws of physics are the same in any inertial frame of reference.
- 2. The speed of light, c , is the same for all observers, no matter what their relative speeds.

• Relativistic Effects

Time and Length are relative.

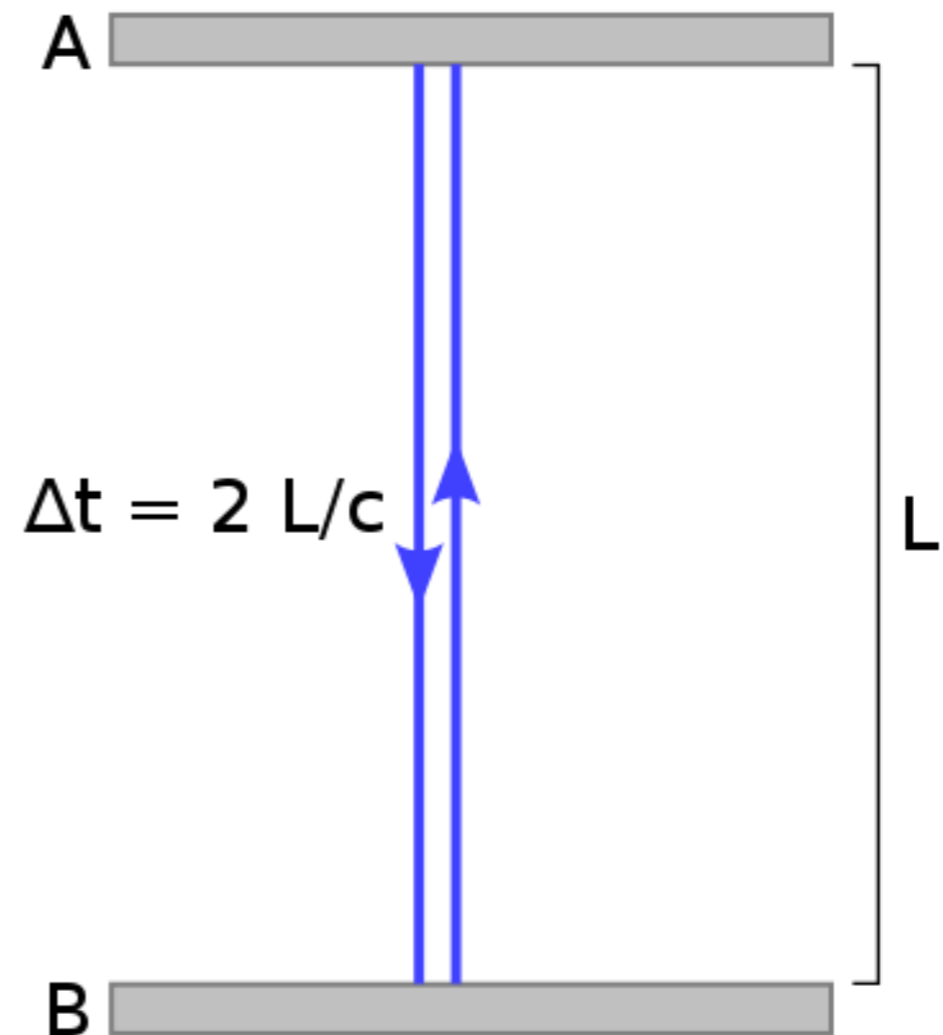
- Time Dilation: A moving clock will tick slower than a stationary clock.
- Length Contraction: A moving object is shortened in the direction of motion.
- Differences are calculated with the Lorentz Factor γ

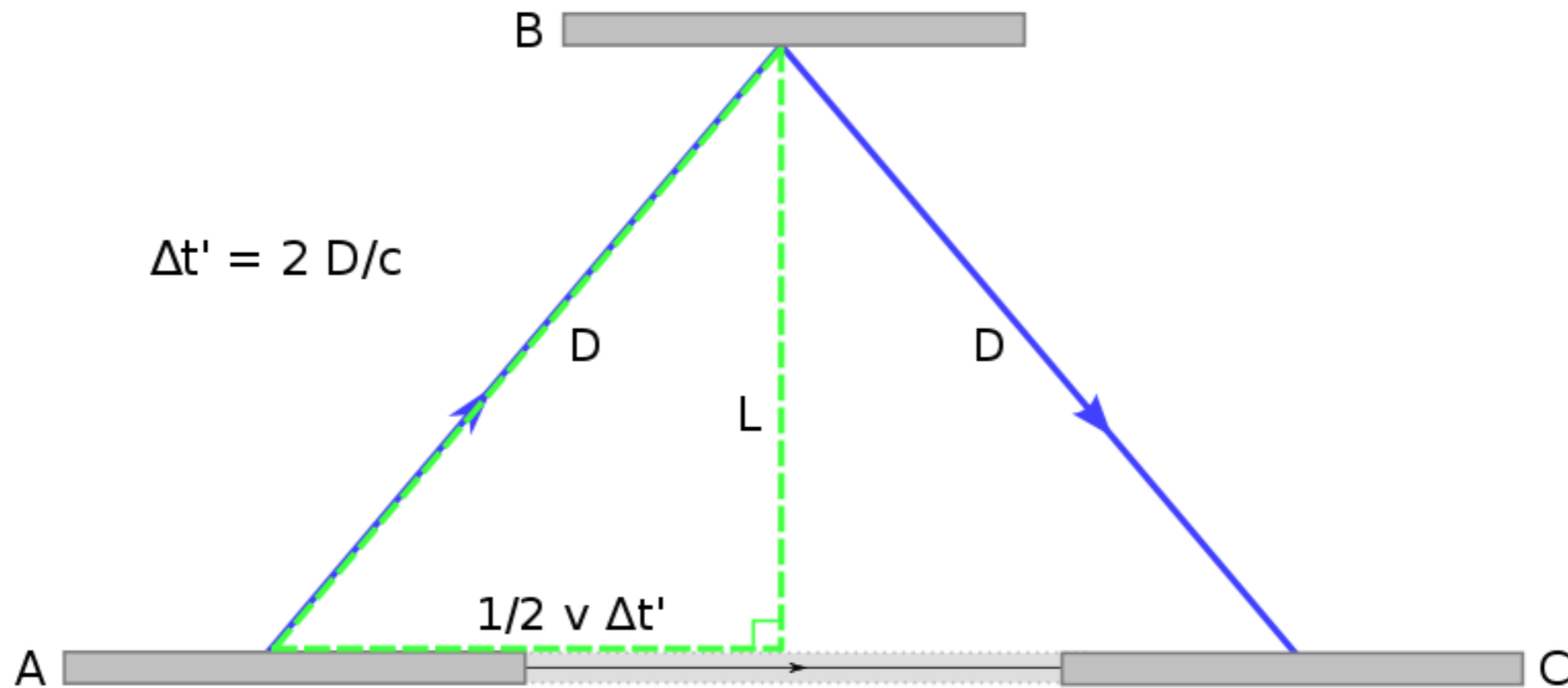


Time Dilation

Simple light clock consisting of two mirrors, A and B, between which a light pulse is bouncing. The distance between the mirrors is represented as L .

In the reference frame that is at rest, the light pulse travels a distance of $2L$. The period of the clock is then $2L$ divided by the speed of light, c .





The light clock as viewed by a moving observer at the speed v . The light pulse takes a longer path and this distance is given as $2D$.

The total time for the light pulse to trace

$$\Delta t' = \frac{2D}{c}$$

Using geometry, the length of half the distance is calculated as

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

Substituting D into the previous equation gives

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

Using the definition of Δt

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

Length Contraction

$$L' = \frac{L}{\gamma(v)} = L \sqrt{1 - v^2/c^2}$$

L is the length of the object in its rest frame

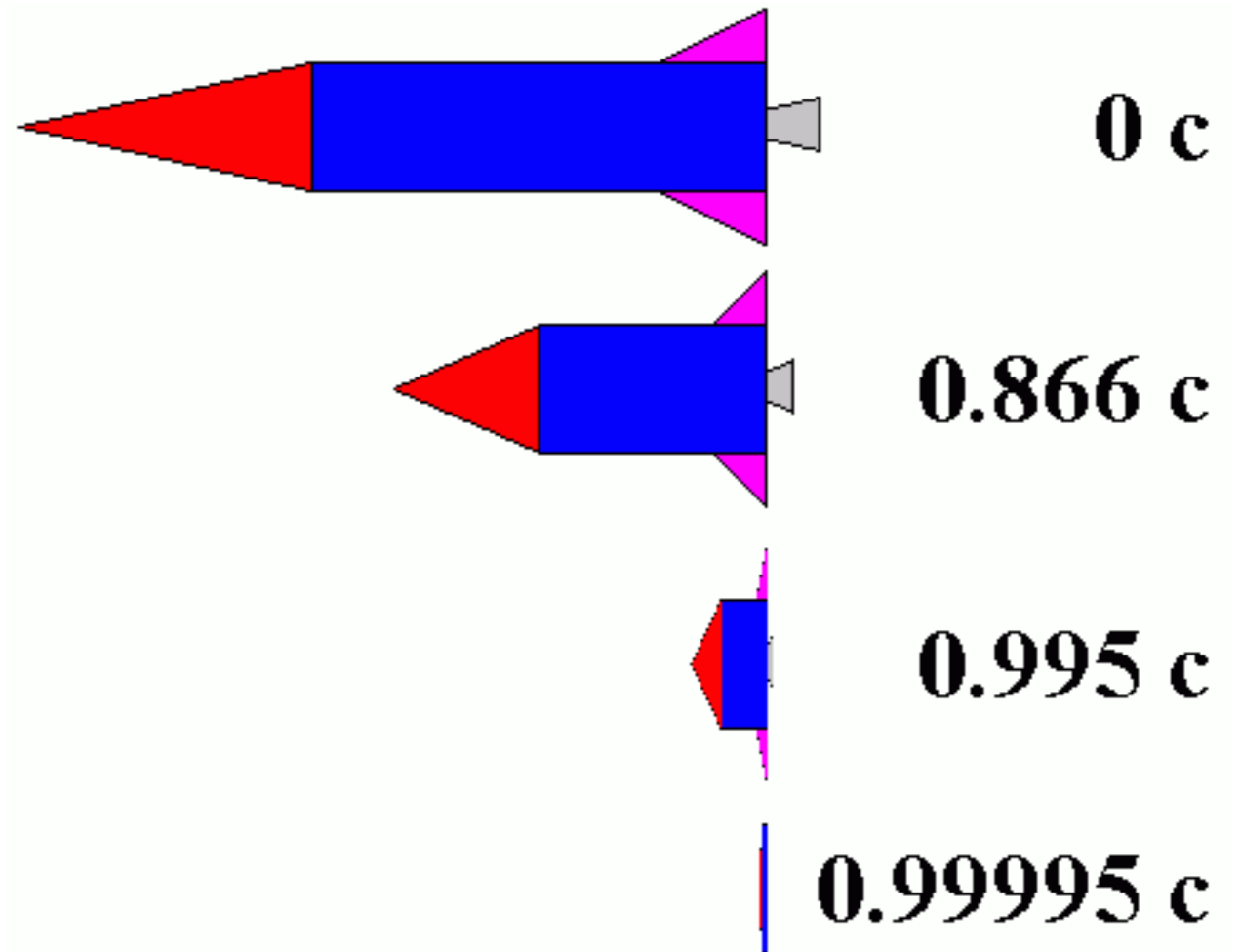
frame

L' is the length observed in relative motion

v is the relative velocity between the observer and the object

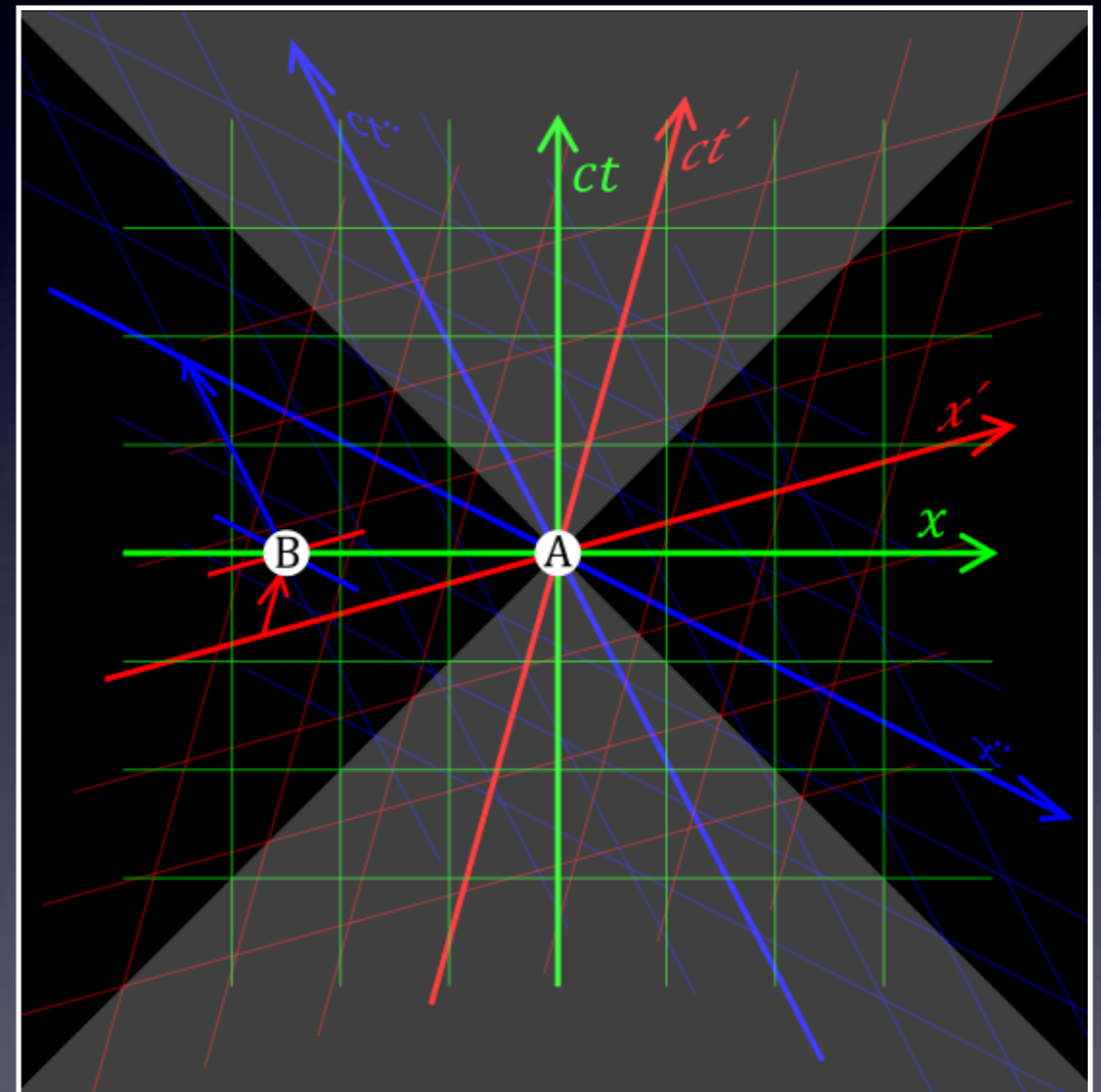
c is the speed of light.

$$\gamma(v) \equiv \frac{1}{\sqrt{1 - v^2/c^2}}$$



Simultaneity

- If an event occurs in a single space, such as a car crash, all observers will agree that both cars arrived at the same time.
- If two events are separated by space, however, a simultaneous event is relative.
- It depends on the observer's reference frame.
- [Video example](#)



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