Postulates

Invariance of physical laws in all inertial frames.

Constancy of the speed of light c in a vacuum.

Helpful Equations

Lorentz Transformation

Let S denote the frame in which we have an event (spacetime point) with coordinates(t, x, y, z).

Then let S' denote the frame in which the coordinates of the event are (t', x', y', z'), and which is traveling with a velocity v with respect to S along the x-axis:

$$\begin{aligned} t' &= \gamma\left(t - \frac{vx}{c^2}\right) \\ x' &= \gamma(x - vt) \\ y' &= y \\ z' &= z \end{aligned}$$

γ is the Lorentz factor. Note that as $v \to 0$, $\gamma \to 1$ (Galilean limit), and as $v \to c$, $\gamma \to \infty$:

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

Sometimes people write $\beta = v/c$, then $\gamma = \frac{1}{\sqrt{1-\beta^2}}$.

A sometimes helpful invariant:

$$(\Delta s)^2 = (c\Delta t)^2 - (\Delta x)^2 - (\Delta y)^2 - (\Delta z)^2$$

The interval between two events is said to be spacelike if $(\Delta s)^2 < 0$, timelike if $(\Delta s)^2 > 0$ and lightlike if $(\Delta s)^2 = 0$. There can be a cause-effect relationship between two points if and only if the spacetime interval is timelike or (if the event is a photon traveling between two points) lightlike.

Velocity addition

If an object appears to travel at velocity w (parallel to v) in S, then it appears to travel at velocity $w' = \frac{w-v}{1-wv/c^2}$ in S'.

Dynamics

Let m_0 be the rest mass of an object. Then if it is moving at $\vec{v}$ in S, then its energy is:

$$E = \gamma m_0 c^2$$

and its momentum is:

$$\vec{p} = \gamma m_0 \vec{v}$$

Furthermore, $E^2 - |pc|^2 = (m_0c^2)^2$, which is invariant. Also, $F = \frac{dp}{dt}$ instead of ma.

Time Dilation / Length Contraction

An object has length L in S, and a time interval has length T in S. Then in S':

$$\begin{aligned} L' &= L/\gamma = L\sqrt{1 - v^2/c^2} \\ T' &= \gamma T = \frac{T}{\sqrt{1 - v^2/c^2}} \end{aligned}$$

The length is contracted and the time is dilated.