

Special Relativity

Postulates of Special Relativity:

Relativity Postulate: the laws of physics are the same in all inertial reference frames

Speed of Light Postulate: the speed of light in vacuum, 3.0×10^8 m/s, is the same in all reference frames, independent of the motion of the source or the observer

Time Dilation:

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

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

Δt_0 (proper time): time measured in a frame of reference where the clock is at rest

Δt (dilated time): time measured in a frame of reference where the clock is moving

⇒ moving clocks run slow

Length Contraction:

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

$$L = \frac{L_0}{\gamma}$$

L_0 (proper length): distance between two points as measured by an observer at rest with respect to them

⇒ length contraction occurs only along the direction of motion

Relativistic Momentum and Energy:

Relativistic Momentum:
$$p = \frac{mv}{\sqrt{1 - v^2/c^2}}$$

Total Energy:
$$E = \frac{mc^2}{\sqrt{1 - v^2/c^2}}$$

Rest Energy: $E_0 = mc^2$

Kinetic Energy:
$$KE = E - E_0 = mc^2 \left(\frac{1}{\sqrt{1 - v^2/c^2}} - 1 \right)$$