1) Principle of relativity
2) Speed of light \( c \) is same in all inertial ref. frames

\[ L = \sqrt{L_0^2 + \frac{\mu^2 (\Delta t)^2}{c^2}} \]

\[ \Delta t = \frac{2L_0}{c} \]

\[ \frac{1}{\sqrt{1-\frac{\mu^2}{c^2}}} = \gamma \]

\[ \Delta t = \gamma \Delta t_0 \]

\[ \Delta t > \Delta t_0 \]
proper time: $\Delta t_0$: measured at same location

improper time $\Delta t$: differs in locations

$\Delta t = \Delta t_0$; $\Delta t > \Delta t_0$

time dilation: moving clock runs slower
\[ L = \mu \Delta t \]
\[ L_0 = \mu \Delta t \]

proper length \( L_0 \)

\[ \frac{\Delta t}{\Delta t_0} \]

propagating is shortest

dt

noon

60 mins

improper

1 pm:

\[ L = \frac{L_0}{\gamma} < L_0 \]

length contraction

\[ \frac{12:59 \text{ pm}}{\text{correct}} \]

what does my wristwatch show?

\[ \frac{1:01 \text{ pm}}{\Delta t_0} \]

1 pm

\[ \Delta t = \gamma \Delta t_0 \]

\[ \gamma > 1 \]
\[ \Delta t = \frac{L_0}{\mu} \]

Time on Earth in spaceship goes from A to B:

\[ \Delta t = \gamma \Delta t_0 \]

Time on ship: \( \Delta t_0 \)

In person on ship, \( L = \mu \Delta t_0 = \frac{\mu \Delta t}{\gamma} = \frac{L_0}{\gamma} < L_0 \)
\[ \Delta t = \gamma \Delta t_0 \quad ; \quad L = \frac{L_0}{\gamma} \]

\textbf{Muons}

\[ \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = 7 \]

\[ \Delta t = \gamma \Delta t = 15 \text{ sec} \]

\[ L_0 = \mu \Delta t \approx 4700 \text{ m} \]

for muon: \[ L = \mu \beta = 650 \text{ m} \]
$\mu \rightarrow$ length doesn't change

$\theta_0$

$\theta$

$L_x = \frac{L_{ox}}{x}$

$\tan \theta = \frac{L_y}{L_x} = \frac{y}{x} \tan \theta_0$

$L_x = L_{ox} / x$

$L_y = L_{oy}$

$\tan \theta_0 = L_y / L_x$
Simultaneity

A → egg → B

Which happened first? Light hits point A first?

Chicken was born first, egg was laid

in the shit, simultaneous
lightning hits front and back simultaneously by
according to observers on ground
for observers on train, lightning hits
first front back
\[ \Delta t = \frac{L}{c} \]