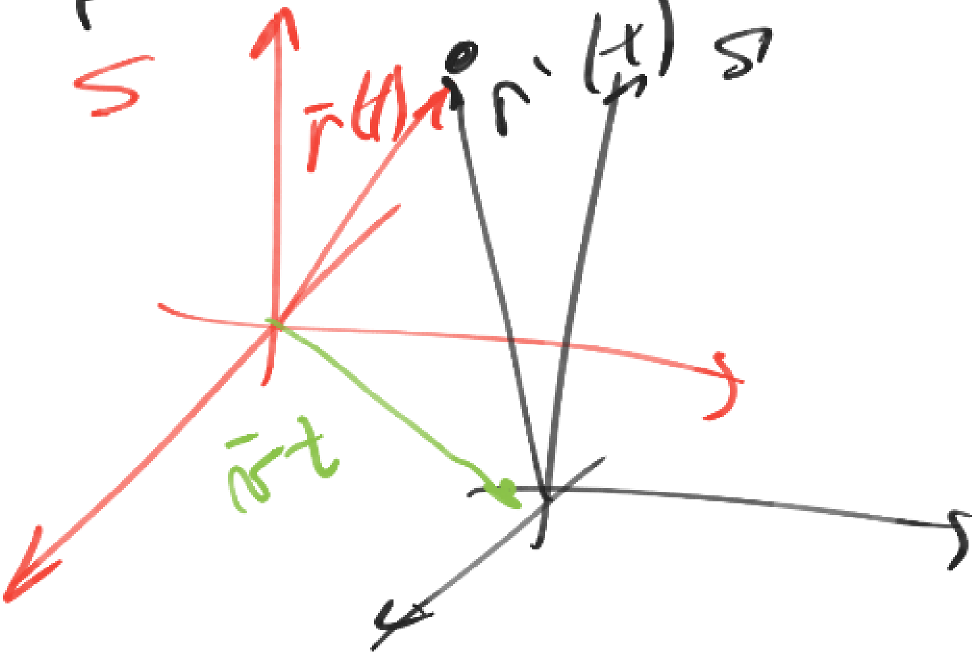
ipac-2019-U01C02-1408-cinematica-relativi...

$$\underbrace{\vec{r}\,'(t)}_{\text{Como lo veo en el sistema primado } S'} = \underbrace{\vec{r}(t)}_{\text{Como lo vemos en } S} - \underbrace{\vec{v}\,t}_{\text{velocidad relativa}}$$



$$\vec{v}(t) = \frac{d\vec{r}}{dt}$$

$$\vec{v}\,'(t) = \frac{d\vec{r}\,'}{dt}$$

$$\frac{d\vec{r}\,'(t)}{dt} = \vec{v}(t) - \vec{v} = \vec{v}\,'(t)$$

$$\vec a(t) = \frac{d^2\vec r(t)}{dt^2} = \frac{d}{dt} v(t) = \frac{dv(t)}{dt}$$

$$\frac{dv'(t)}{dt} = \frac{d}{dt}\left(\vec v(t) - \vec{V}\right) = \underbrace{\frac{d\vec v}{dt}}_{\vec a} + \cancel{\frac{d\vec V}{dt}}^{\,0}$$

$$\boxed{a'(t) = a(t)}$$

$$\vec F = m\vec a(t) = m a'(t) = \vec F'$$

Ecuacion de la mecánica son covariantes.

$$t' \equiv t$$

$$\downarrow$$

$$dt' \equiv dt$$

$$\frac{d}{} = \frac{d}{}$$

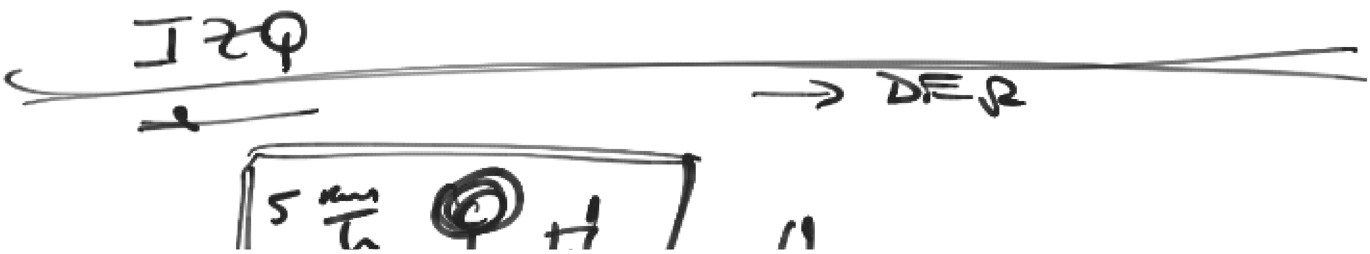
$$dt' = dt$$

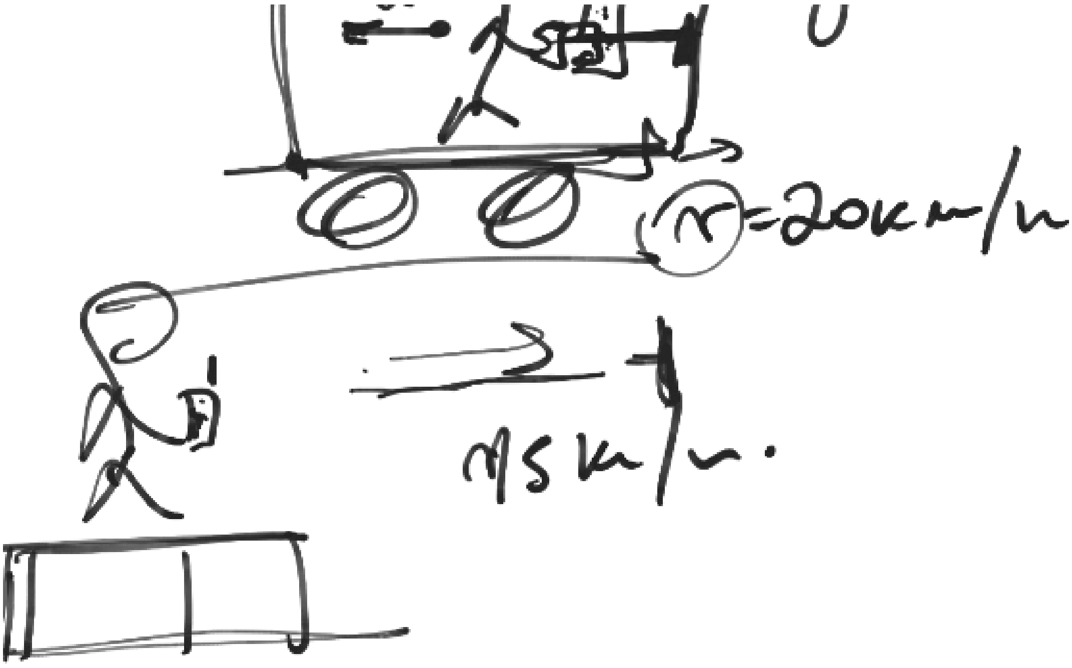
Para cargas en movimiento tengo que usar otra transf. Galileo no anda

$\simeq$

29,7 km/s.

$10^{-4} c$





$$\vec{v} = \frac{\Delta \vec{r}}{\Delta t} \qquad \Big\| \qquad \bar{v}' = \frac{\Delta r'}{\Delta t}$$

$$c = \frac{\Delta r}{\Delta t} \qquad \Big\| \qquad c' = \frac{\Delta r'}{\Delta t}$$

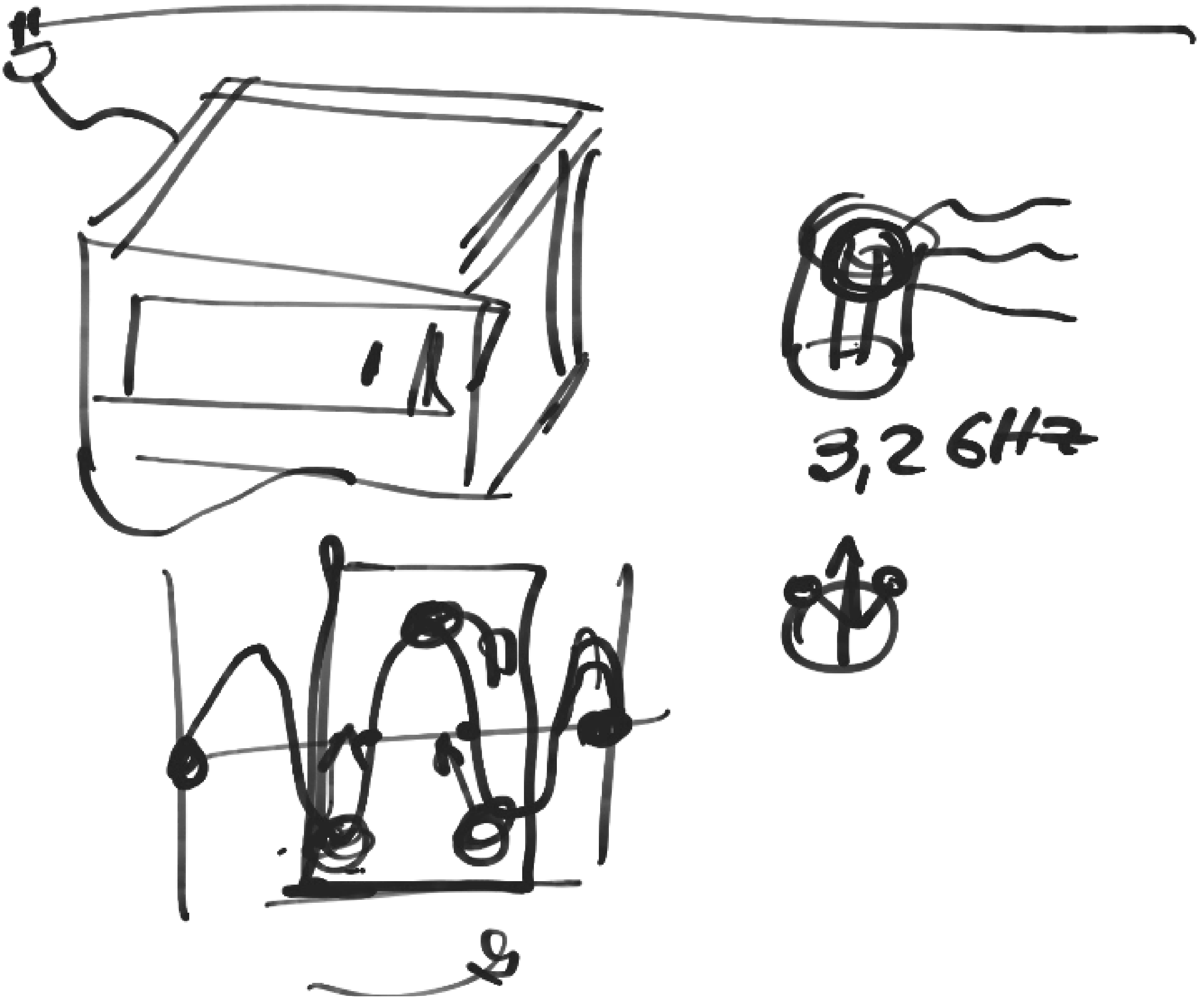
$$\boxed{c = c'}$$

$$\Delta t \neq \Delta t'$$

$$t \neq t'$$

$$dt \cancel{\equiv} dt'$$

$$\boxed{\cancel{\frac{d}{dt} = \frac{d}{dt'}}}$$



Queso mantico.

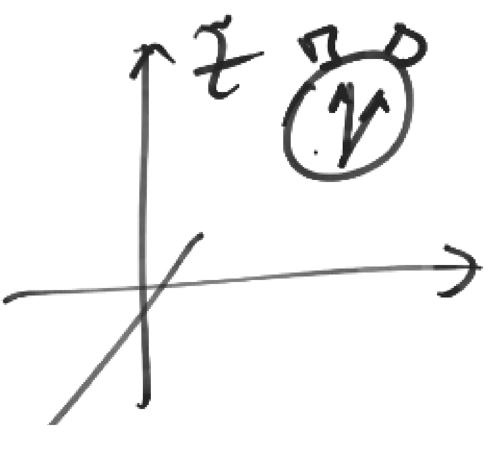
$\Delta L \sim \lambda$

f

$\boxed{c = \lambda f}$

$\Delta L \sim \lambda$

Marco de referencia



$S(x, y, z, t)$

y $S'(x', y', z', t')$

7/10 evento → punto en este espacio 4-tupla

$\boxed{\text{Espacio-tiempo.}}$

$$t' = \gamma\,(t - v x)$$
$$x' = \gamma\,(x - v t)$$

$c = 1$

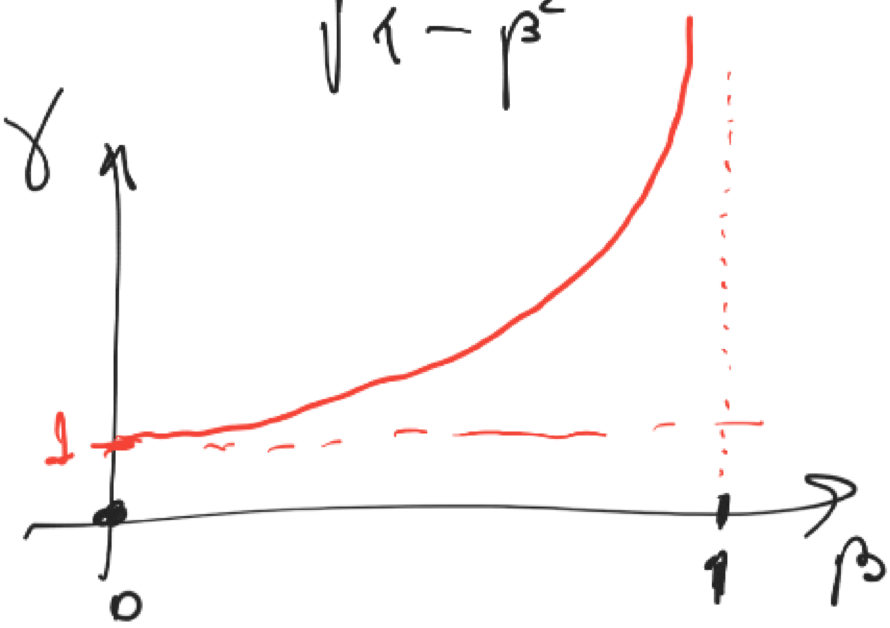
γ factor de Lorentz.

$$\gamma = \frac{1}{}.$$

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

$\frac{v}{c} \equiv \beta < 1$ Salvo para la luz $\beta = 1$

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} = (1-\beta^2)^{-1/2}$$



$$t' = \gamma\left(t - \frac{1}{c^2} v x\right)$$

$$x' = \gamma(x - vt)$$

Si $\beta \to 0$ $(v \to 0) \to v \ll c$

$\gamma \to 1$

$$x' = \gamma(x - vt) \quad \gamma \to 1.$$

$$\boxed{x' \simeq (x - vt)}$$

transf. de Galileo.

$$t' = \overset{\nearrow 1}{\gamma}\left(t - \underbrace{\frac{1}{c^2} vx}_{\to 0}\right) \nearrow 0.$$

$\gamma \to 1$

$v \to c$

$$\boxed{t' = t}$$

$$v \ll c$$

transf Lorentz $\to$ transf. de Galileo.

$$\bar{a}' = \bar{a}$$

$$t' = \gamma\left(t - \frac{1}{c^2} vx\right)$$

$$x' = \gamma(x - vt)$$

Galileo!

$$\boxed{v' = dx'} \qquad dx' \qquad t = t'$$

$$\frac{\ }{dt'} \qquad \frac{\ }{dt}$$

Einstein.

$$dx' = \gamma \left(dx - v\,dt \right)$$

$$dt' = \gamma \left(dt - \frac{1}{c^2} v\,dx \right)$$

$$v' = \frac{dx'}{dt'} = \frac{\cancel{\gamma} \left(dx - v\,dt \right)}{\cancel{\gamma} \left(dt - \frac{1}{c^2} v\,dx \right)}$$

$$v' = \frac{\cancel{dt} \left(\overbrace{dx/dt}^{u} - v \right)}{\cancel{dt} \left(1 - \frac{1}{c^2} v \underbrace{dx/dt}_{u} \right)}$$

$$\boxed{\bar{u}' = \frac{\bar{u} - \bar{v}}{1 - \frac{\bar{u} \cdot \bar{v}}{c^2}}}$$

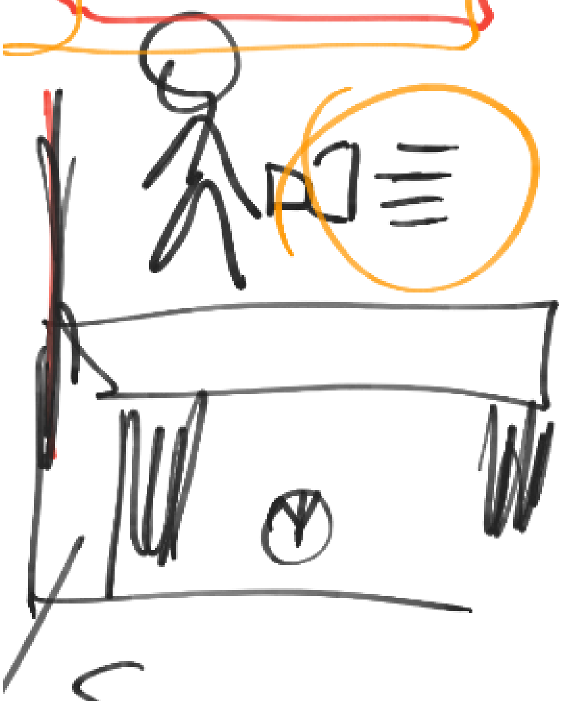
transf. de velocidades

de ...

$$v = \frac{dx}{dt} \rightarrow \boxed{\vec{u} = \frac{\vec{u}' + \vec{v}}{1 + \frac{\vec{u}' \cdot \vec{v}}{c^2}}}$$

$(v$ ó $u) \ll c \rightarrow$ Galileo.

$u \rightarrow c$



S

Si uso Galileo

$u' = u - v$

$$c' = c - v \neq c$$

<u>Einstein.</u>

$$U' = \frac{U - v}{1 - \frac{U \cdot v}{c^2}}$$

$$U = c$$

$$U' = \frac{c - v}{1 - \frac{\cancel{c}\, v}{c^{\cancel{2}}}} = \frac{c - v}{1 - \frac{v}{c}}$$

$$U' = \frac{c - v}{\left(\frac{c - v}{c}\right)} = \cancel{\left(\frac{c - v}{c - v}\right)} \frac{1}{c}$$

$$\boxed{U' = c \quad = U}$$

Consecuencias del segundo Postulado.

$$t' = \gamma\left(t - \frac{1}{c^2} v x\right)$$

$$x' = \gamma\left(x - v t\right)$$

$$t_1' = \gamma\left(t_1 - \frac{1}{c^2} v x_1\right)$$

$$t_2' = \gamma\left(t_2 - \frac{1}{c^2} v x_2\right)$$

$$\Delta t' = t_2' - t_1' = \gamma\left(t_2 - \frac{1}{c^2} v x_2\right) - \gamma\left(t_1 - \frac{1}{c^2} v x_1\right)$$

$$= \gamma\left(t_2 - \frac{1}{c^2} v x_2 - t_1 + \frac{1}{c^2} v x_1\right)$$

$$= \gamma\left((t_2 - t_1) + \frac{1}{c^2} v\left(-x_2 + x_1\right)\right)$$

$$= \gamma\left(\Delta t - \frac{1}{c^2} v \Delta x\right) = \Delta t'$$

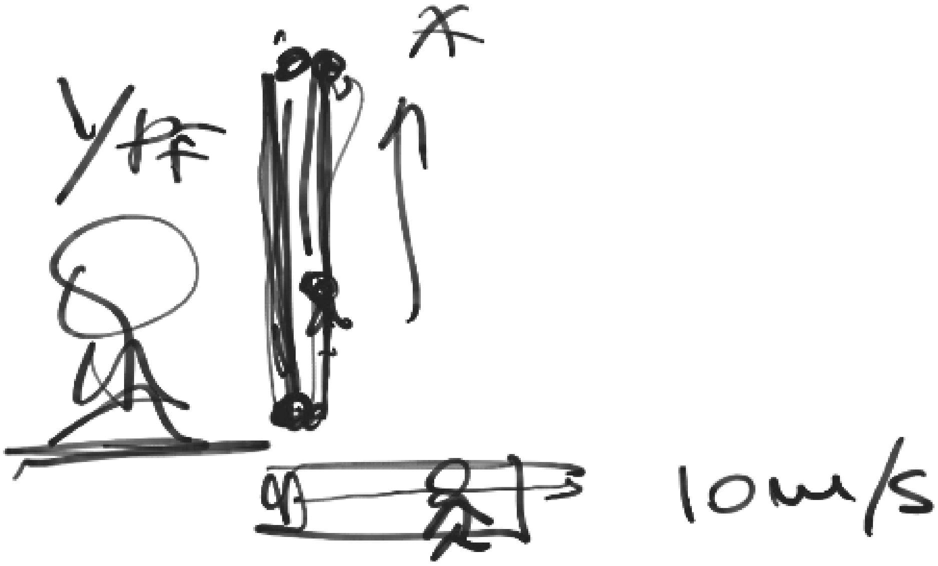
$$\gamma\left(\Delta t \quad \frac{\ }{c^2} \quad \right)$$

$$\Delta t' = \gamma\left(\Delta t - \frac{1}{c^2} v \Delta x\right)$$

$$\rightarrow \Delta x' = \gamma\left(\Delta x - v \Delta t\right)$$

$$\Delta t = \gamma\left(\Delta t' + \frac{1}{c^2} v \Delta x'\right)$$

$$\Delta x = \gamma\left(\Delta x' + v \Delta t'\right)$$



$$\Delta x' = \gamma\left(\Delta x - v \Delta t\right)$$

$\Delta t = 1s.$

$\Delta x = 100m,$

$$\Delta x' = \gamma\left(100\,m - 10\,\frac{m}{\cancel{s}} \cdot 1\,\cancel{s}\right)$$

$$\Delta x' = 90\,m.$$

$$\Delta t' = \gamma\left(\Delta t - \frac{1}{c^2}\, v\, \Delta x\right)$$

$$\Delta t' = \gamma\left(1s - \frac{1}{c^2} \cdot 10\,\frac{m}{s} \cdot 100\,m\right)$$

$$= \gamma\left(1s - \frac{1}{(3\times10^8)^2\,\frac{m^2}{s^2}} \cdot 1000\,\frac{m^2}{s}\right)$$

$$\Delta t' = \gamma\left(1s - \frac{1000}{9\times10^{16}}\,s\right)$$

~ 1 $\qquad\qquad \approx 0.$

$v = 0{,}5c \qquad \gamma = 1{,}15$

$0{,}5$

$$\frac{1}{\ } \left(\frac{v}{\ }\right) \Delta x = 0{,}5 \cdot \frac{100\,m}{3\times10^{8}\ldots}$$

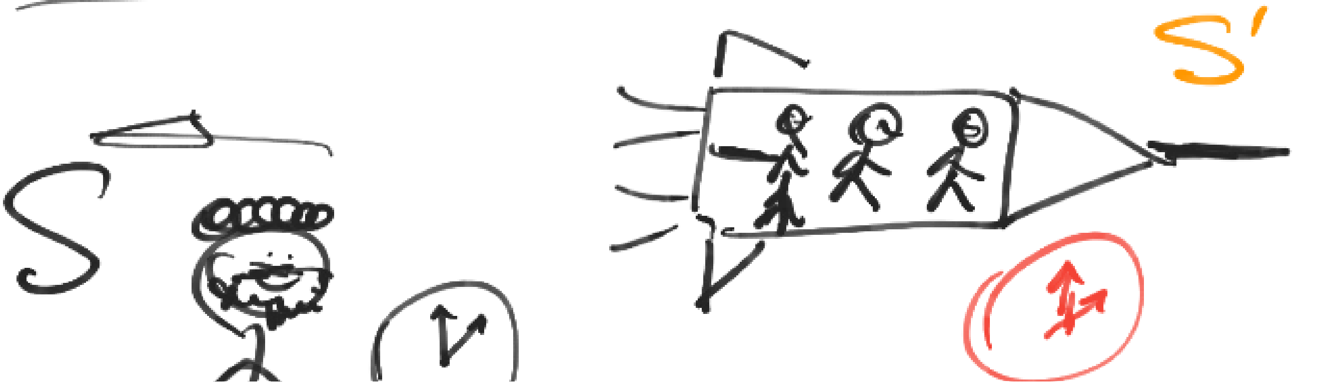
c \c/ 3x10^8 m/s

$= 1{,}7 \times 10^{-7}$ s.

$\Delta t' = 1{,}15 \left(1s - 1{,}7 \times 10^{-7} s \right)$

$\Delta t' = 1{,}14999$ s

$\Delta t = 1$ s.



 poso 1 seg.

$v = 0{,}86c$

$$\Delta t' = \gamma\left(\Delta t - \frac{1}{c^2} v \Delta x\right)$$

$$\Delta x' = \gamma\left(\Delta x - v \Delta t\right)$$

$K_1 = (0, x_1, y_1, z_1)$ $\quad \Delta x = 0$

$K_2 = (1, x_1, y_1, z_1)$ $\quad \Delta t = 1s$

$\gamma = 2$

$$\Delta t' = 2\left(1s - \frac{1}{c^2} v \cancelto{0}{\Delta x}\right)$$

$$\Delta t' = 2 \cdot 1s = 2s.$$

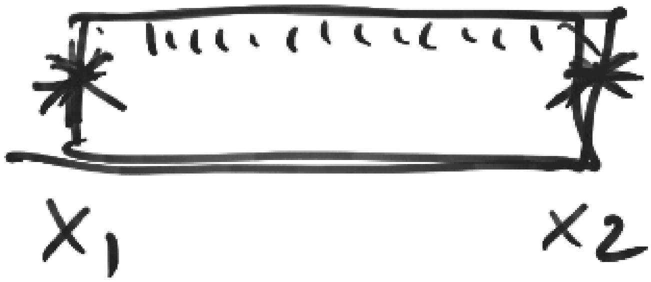
∞

$\Delta t = 1s$ y $v \to c \Rightarrow$

$$\Delta t' \to \infty$$

$$K_1 = (t_1, x_1, y_1, z_1)$$

$$K_2 = (t_1, x_2, y_1, z_1)$$



$$\Delta t = 0$$

$$\Delta x = x_2 - x_1 = 1\,m$$

$$\Delta x' = \gamma(\Delta x - v\cancel{\Delta t})$$ so,

$$\Delta x' = \gamma \Delta x$$

$$\underline{\Delta x} = \frac{\Delta x'}{\gamma} <$$

$\gamma > 1$

Limitación de Hertz
espacial.

Última modificación: 23:14