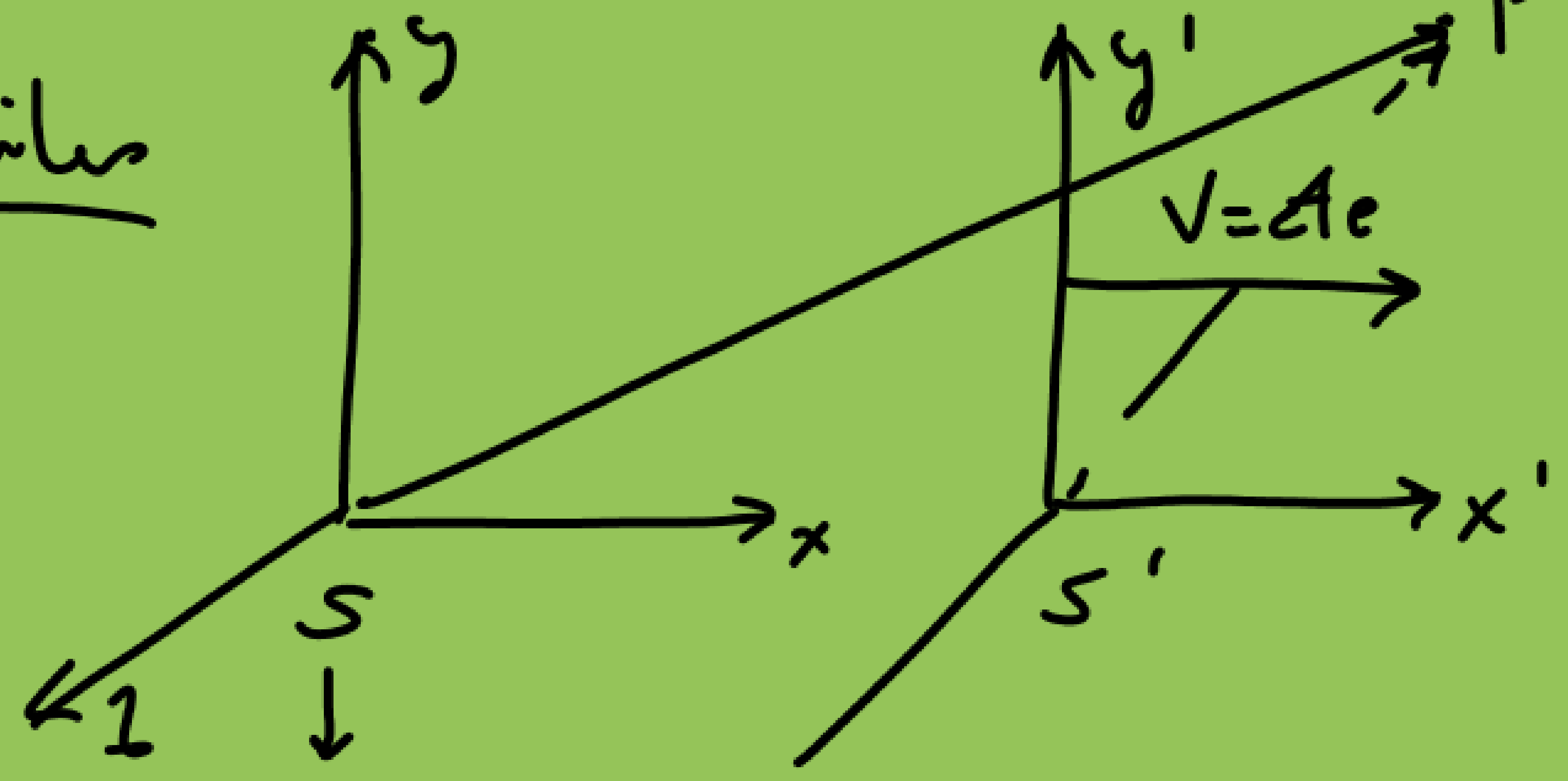
UNIDAD 1 INTRODUCCIÓN A LA RELATIVIDAD

PRINCIPIO DE RELATIVIDAD

Galileo



S → estacionario.

LAS ECUACIONES DE LA MECÁNICA SON = SRI

$$x = x' + Vt$$
$$y = y'$$
$$z = z'$$
$$t = t'$$

$$\frac{dx}{dt} = \frac{dx'}{dt'} + V$$

$$\boxed{u = u' + V}$$

$$a = a'$$
$$\boxed{F = ma = ma'}$$

$$\vec{\nabla}\cdot\vec{E} = \cancel{\rho/\varepsilon}\; 0$$
$$\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}$$
$$\vec{\nabla}\cdot\vec{B} = 0$$
$$\vec{\nabla}\times\vec{B} = \cancel{\mu_0 J}\; 0 + \frac{\partial E}{\partial t}\mu\varepsilon$$

$$\vec{\nabla}\times(\vec{\nabla}\times\vec{E}) = \vec{\nabla}(\cancel{\vec{\nabla}\cdot\vec{E}}) - \nabla^2\vec{E}$$

$$\vec{\nabla}\times\left(-\frac{\partial\vec{B}}{\partial t}\right)$$

$$(\mu\varepsilon) - \frac{\partial}{\partial t}(\vec{\nabla}\times\vec{B}) = \frac{\partial^2\vec{E}}{\partial t^2}(\mu_0\varepsilon_0)$$

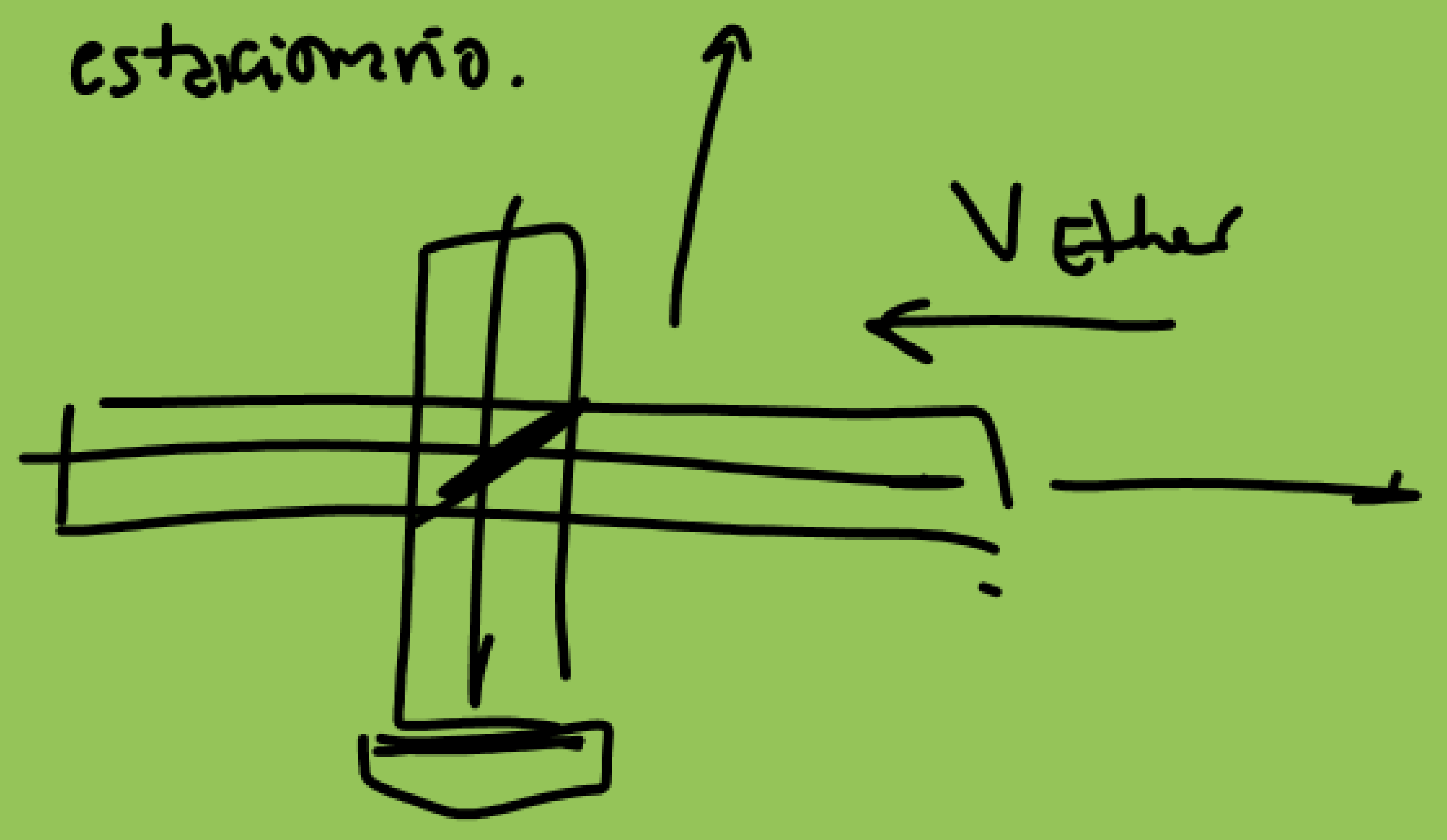
$$\vec{\nabla}^2\vec{E} - \varepsilon\frac{\partial^2\vec{E}}{\partial t^2}$$

$$\boxed{\nabla^2 E - \frac{1}{c^2}\frac{\partial^2 E}{\partial t^2} = 0}$$

$$\boxed{\nabla^2 B - \frac{1}{c^2}\frac{\partial^2 B}{\partial t^2} = 0}$$

$$c = \frac{1}{\sqrt{\mu\varepsilon}}$$

$3\cdot 10^8$ m/s



1.2 PRINCIPIO DE RELATIVIDAD ESPECIAL

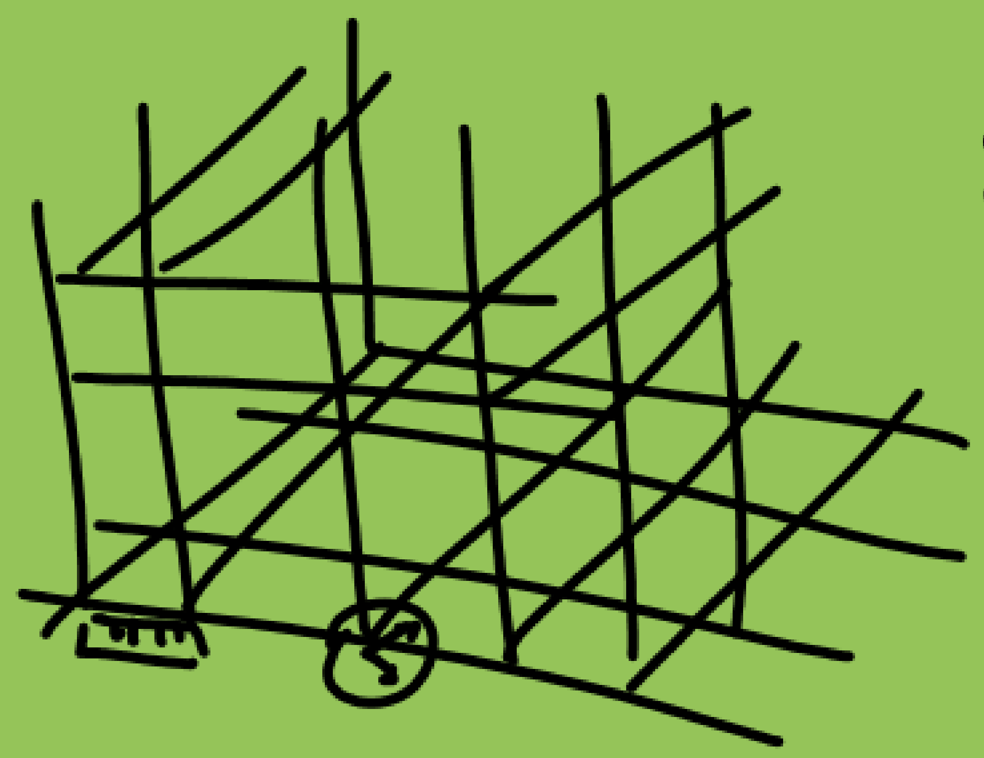
LAS LEYES DE LA FÍSICA SON LA MISMAS EN TODOS LOS SISTEMAS DE REF. INERCIALES

FÍSICA — NEWTON
— MAXWELL

LA CONSTANCIA DE LA VELOCIDAD ES UNA LEY DE LA FÍSICA

$c = cte$

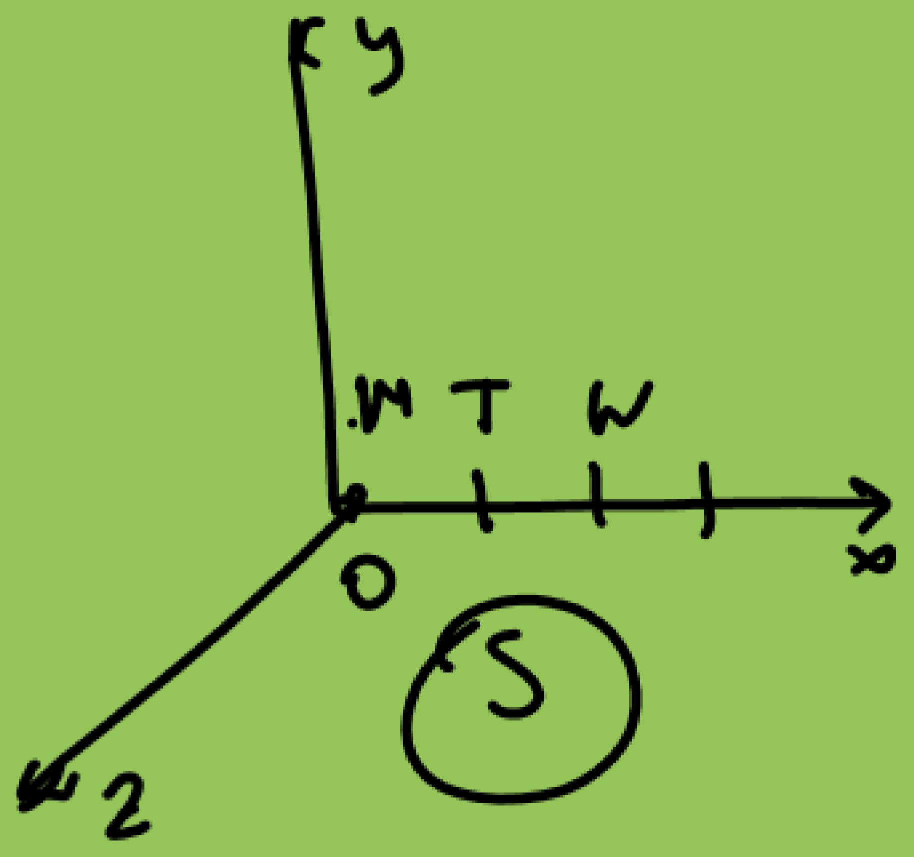
SRI

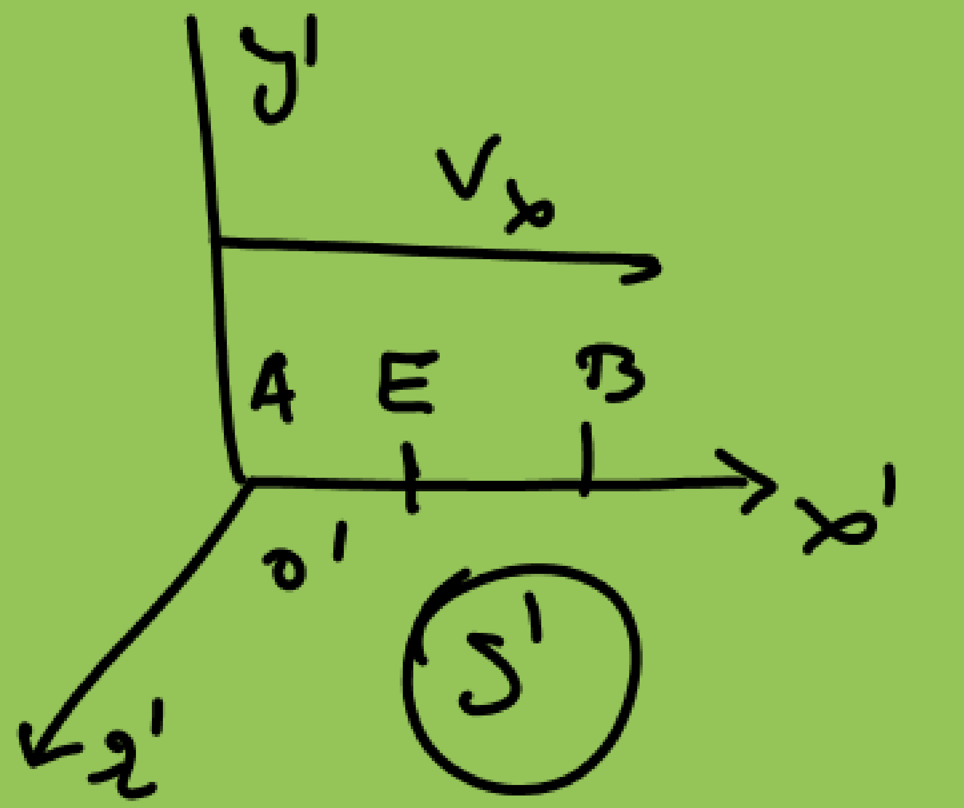


S' [Alice, Bob, Eve]

[Mallory, Trent, Walter] S

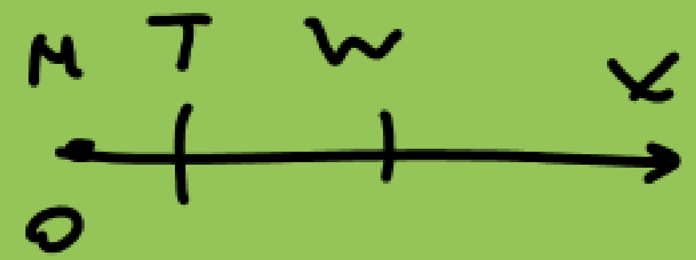
Donde vivas ¿?





Natural units.

$$\boxed{\hbar = c = 1}$$



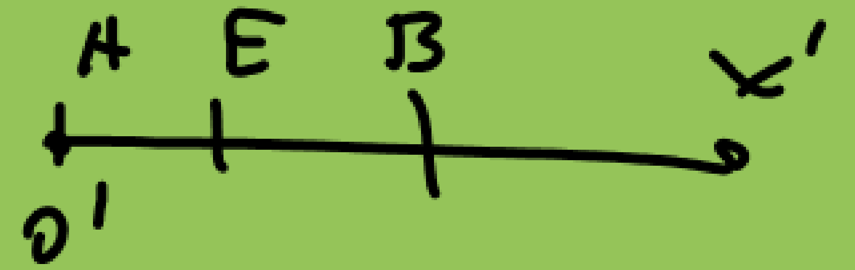
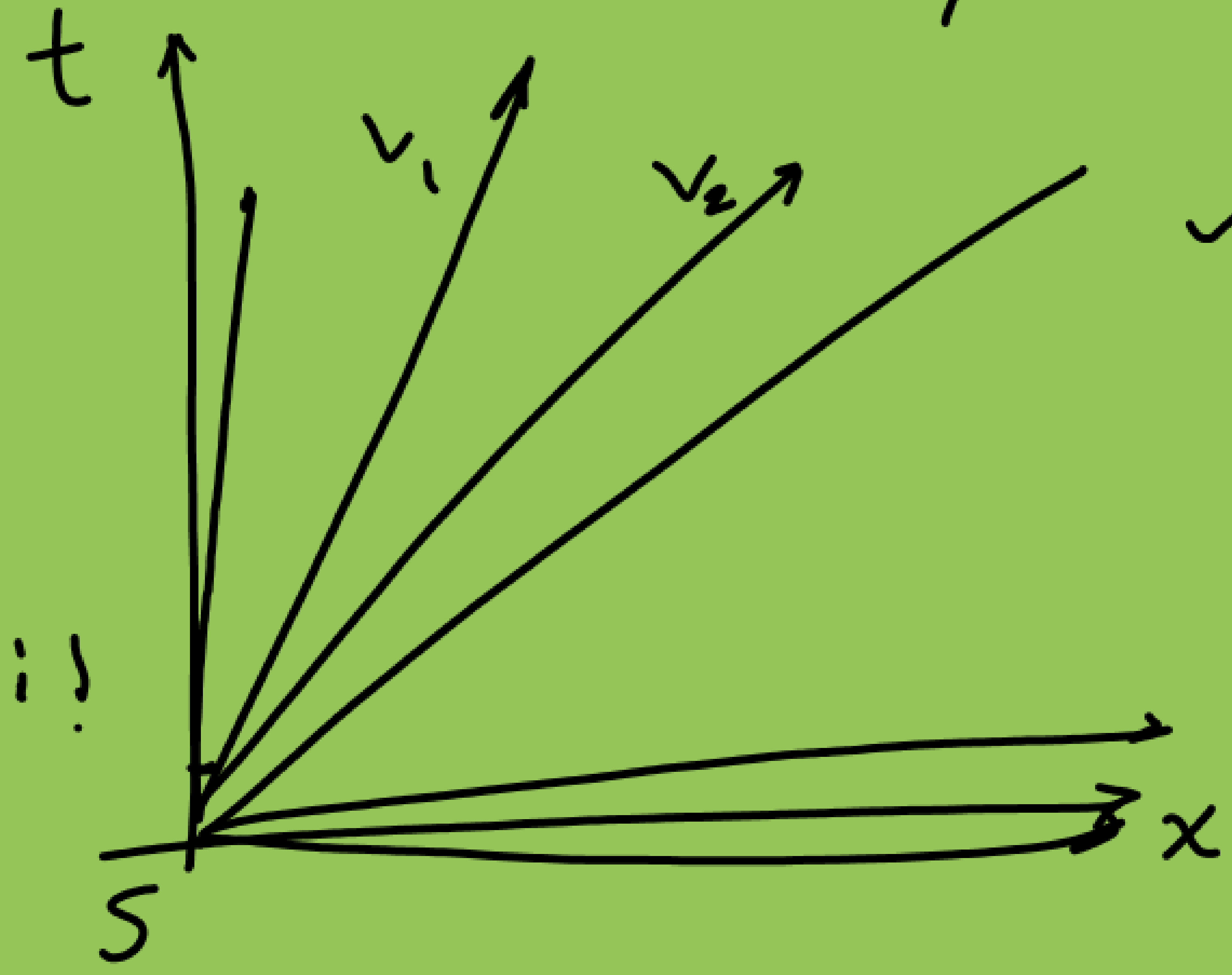


Diagrama Espacio-Temporal ó de Minkowski



$x = ct$

$x = t$

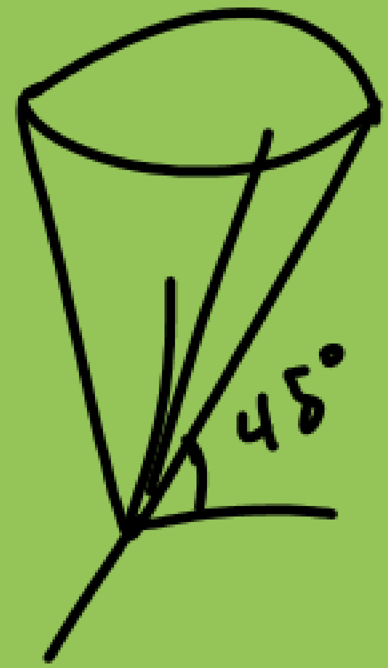
t	x	c
s	1s	1s/s = 1
h	1h	1
y	1y	1

¡\ ¿

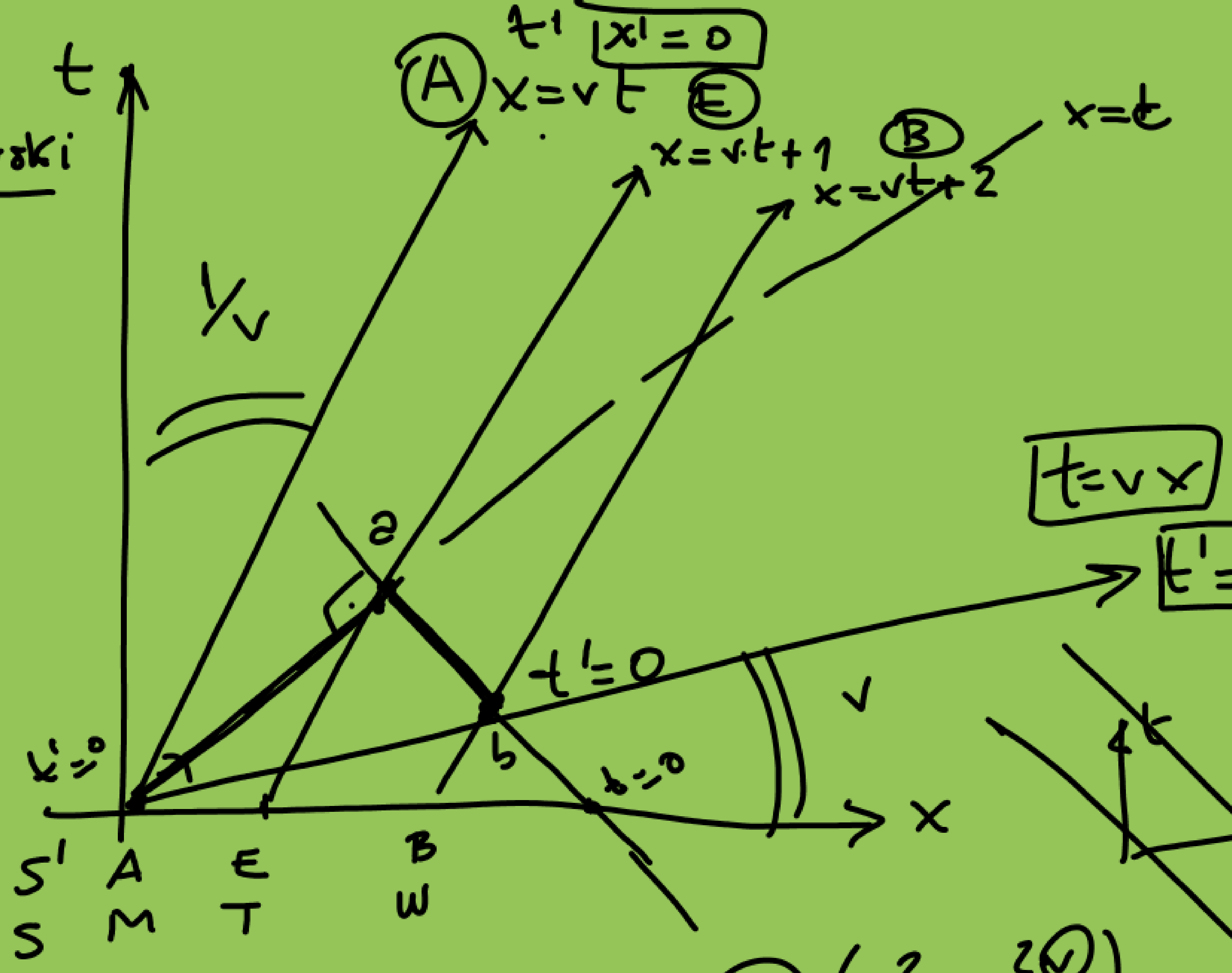
$\boxed{t}$

$x = t$

$x = v\,t$ $v = 0.5$



<u>Minkowski</u>

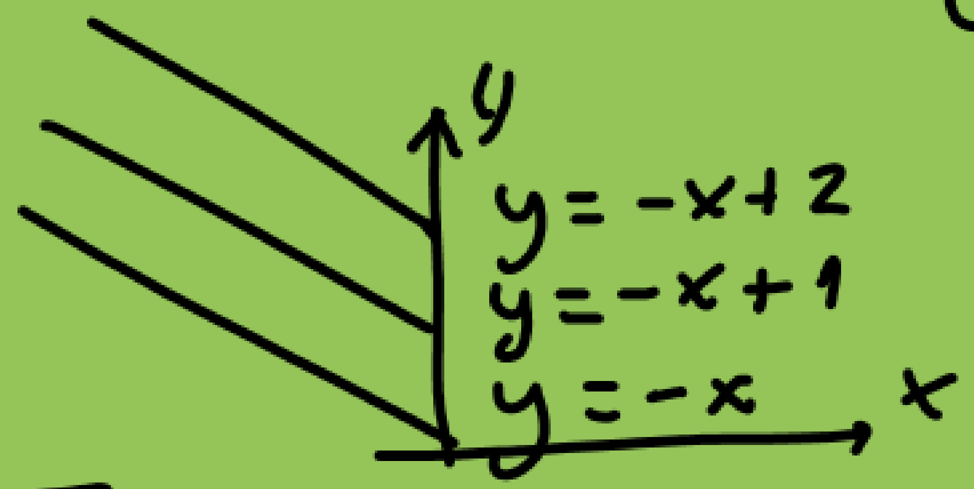


i) $\left.\begin{array}{l} x = t \\ x = vt + 1 \end{array}\right\}$ $t = vt + 1$

$t(1 - v) = 1 \longrightarrow t = \dfrac{1}{1-v}$

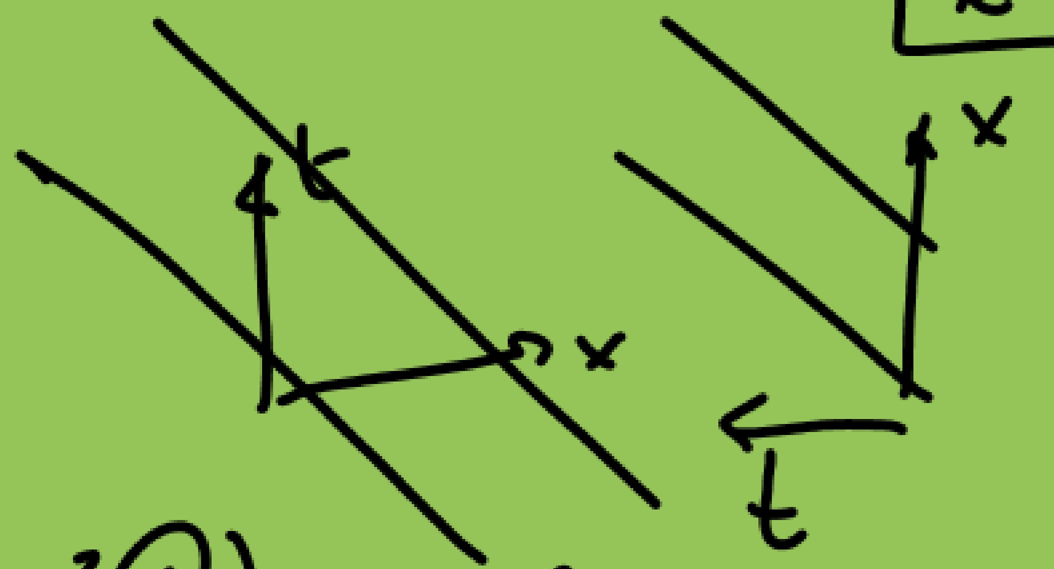
$x = \dfrac{1}{1-v}$

a $\left(\dfrac{1}{1-v}, \dfrac{1}{1-v}\right)$



$\underline{x + y = k}$

ii) $\boxed{x + t = k} \longrightarrow \dfrac{2}{1-v} = k$



$\begin{cases} x + t = \dfrac{2}{1-v} \longrightarrow x = \dfrac{2}{1-v} - t \\ x = vt + 2 \end{cases}$

$vt + 2 = \dfrac{2}{1-v} - t$

$(1+v)t = \dfrac{2}{1-v} - \dfrac{2(1-v)}{1-v}$

$(1+v)t = \dfrac{\cancel{2-2}+2v}{1-v} = \dfrac{2v}{1-v}$

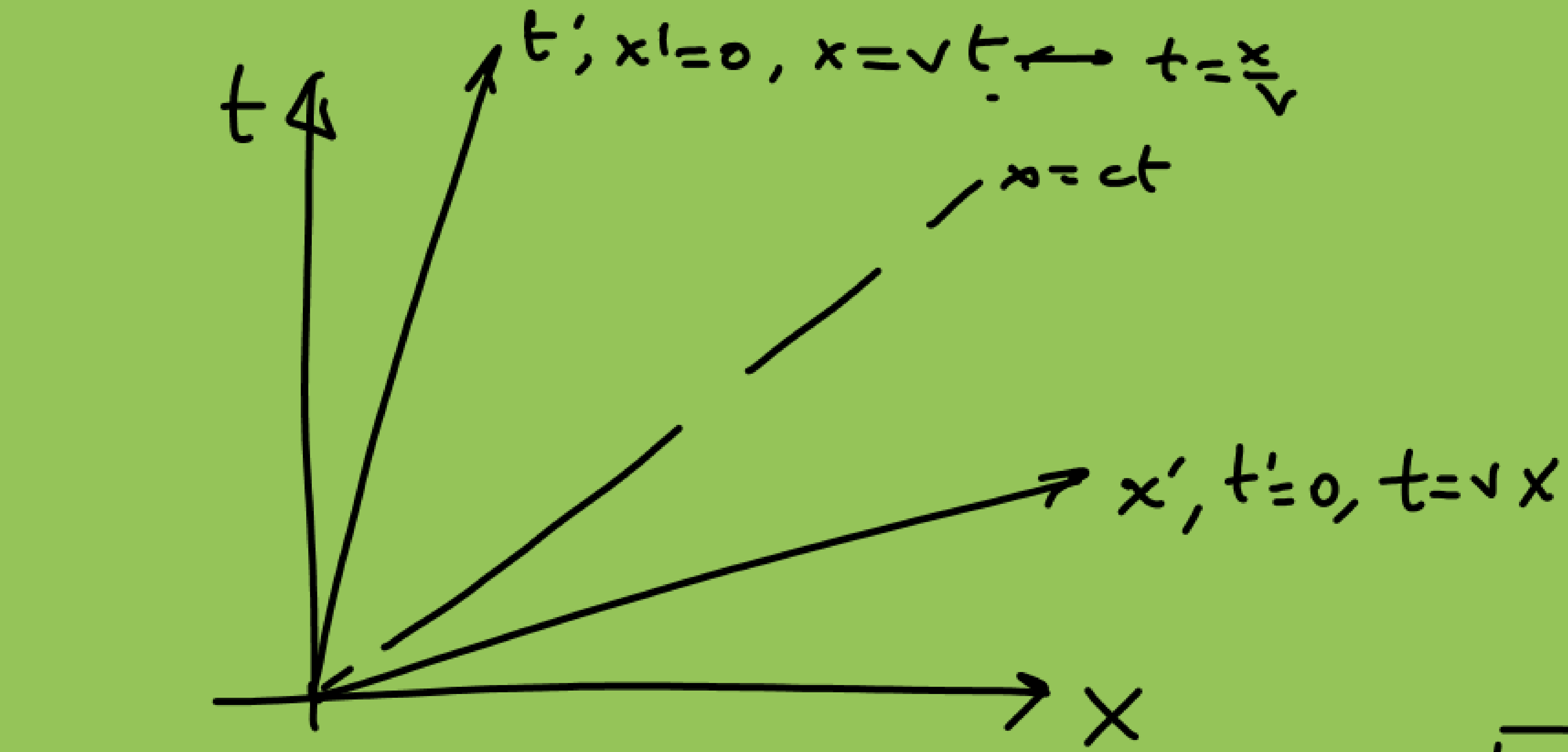
b $\left(\dfrac{2}{1-v^2}, \dfrac{2v}{1-v^2}\right)$

$\boxed{t = mx = vx}$

$t_b = \dfrac{2v}{1-v^2}$

$x_b = \dfrac{2v^2}{1-v^2} + 2 = \dfrac{\cancel{2v^2} + 2(1-\cancel{v^2})}{1-v^2}$

$x_b = \dfrac{2}{1-v^2}$



$$x' = (x - vt)\,f(v)$$
$$t' = (t - vx)\,g(v) \longleftrightarrow f(v)$$

$$x = t$$
$$x' = t'$$

$$x' = (t - vt)\,f(v)$$
$$t' = (t - vt)\,g(v)$$

$$f(v) = g(v)$$

$$S \longleftrightarrow S'$$
$$(t, x) \quad (t', x')$$

$$S \to S' \quad \boxed{\begin{aligned} x' &= (x - vt)\,f(v) \\ t' &= (t - vx)\,f(v) \end{aligned}}$$

$$S' \to S \quad \boxed{\begin{aligned} x &= (x' + vt')\,f(v) \\ t &= (t' + vx')\,f(v) \end{aligned}}$$

$$x = \Big(\underbrace{(x - vt)f(v) + v(t - vx)f(v)}_{(x' + vt')}\Big) f(v)$$

$$x = \left[x - \cancel{vt} + \cancel{vt} - v^2 x\right] f^2(v)$$

$$\cancel{x} = f^2(v)\,\cancel{x}\,(1 - v^2)$$

$$f(v)^2 = \frac{1}{1 - v^2} \longrightarrow \gamma^2 = \frac{1}{1 - v^2}$$

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

$$x' = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}(x - vt)$$

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

$$x = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}(x' + vt')$$

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

transformaciones de Lorentz

$$S \longleftrightarrow S'$$

$$\frac{v}{c} << 1 \qquad \gamma = \frac{1}{\sqrt{1-v^2}} = 1 \longrightarrow \underline{x' = x - vt}$$

$$\underline{v = 0.999\,c}$$

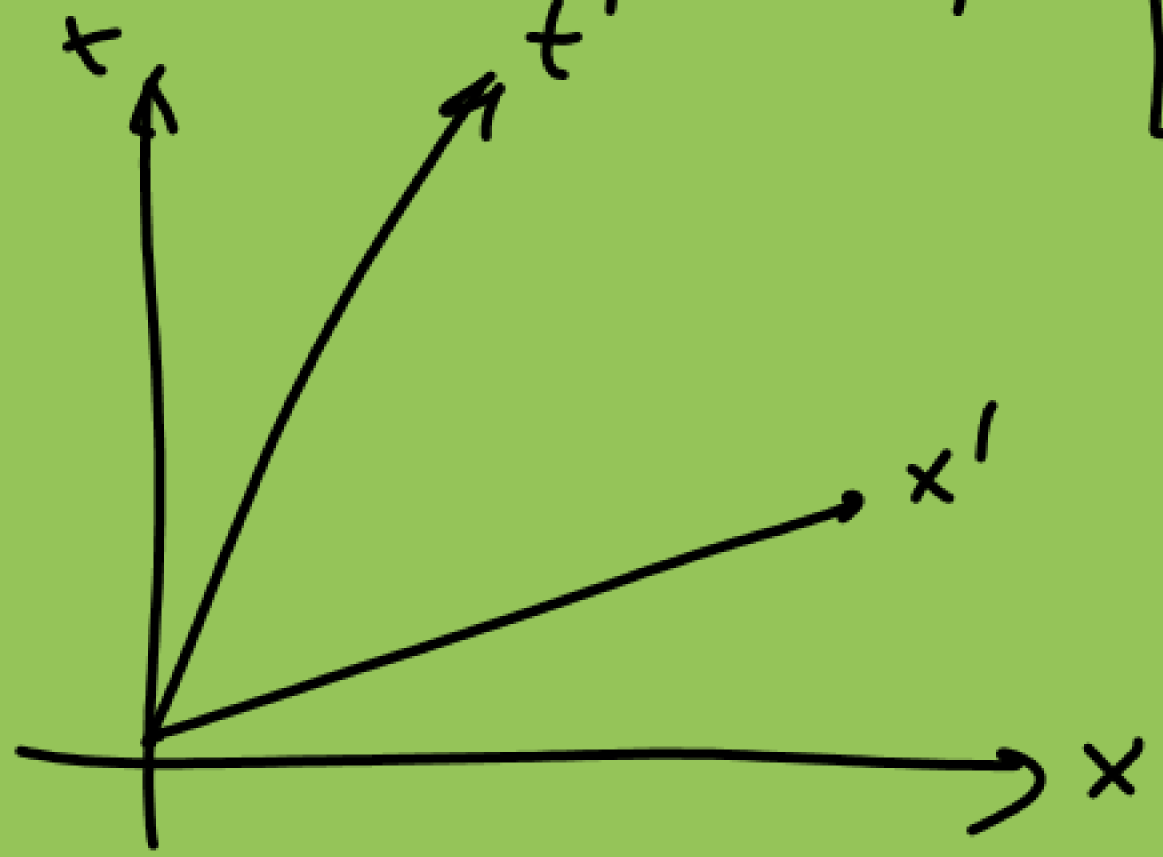
$$\frac{v\,x}{c^2} = \frac{\cancel{L}/\cancel{T}\,\cancel{L}}{\cancel{L^2}/T^{\cancel{2}}} = T$$

$$\frac{t}{v}$$

$$\frac{v}{c}t = \frac{\cancel{L}\,\cancel{T}}{\cancel{T}\,L^2/T^2} = \frac{T^{?}}{L}$$

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

$$x = \gamma(x' + vt')$$
$$t = \gamma(t' + vx')$$



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

ct

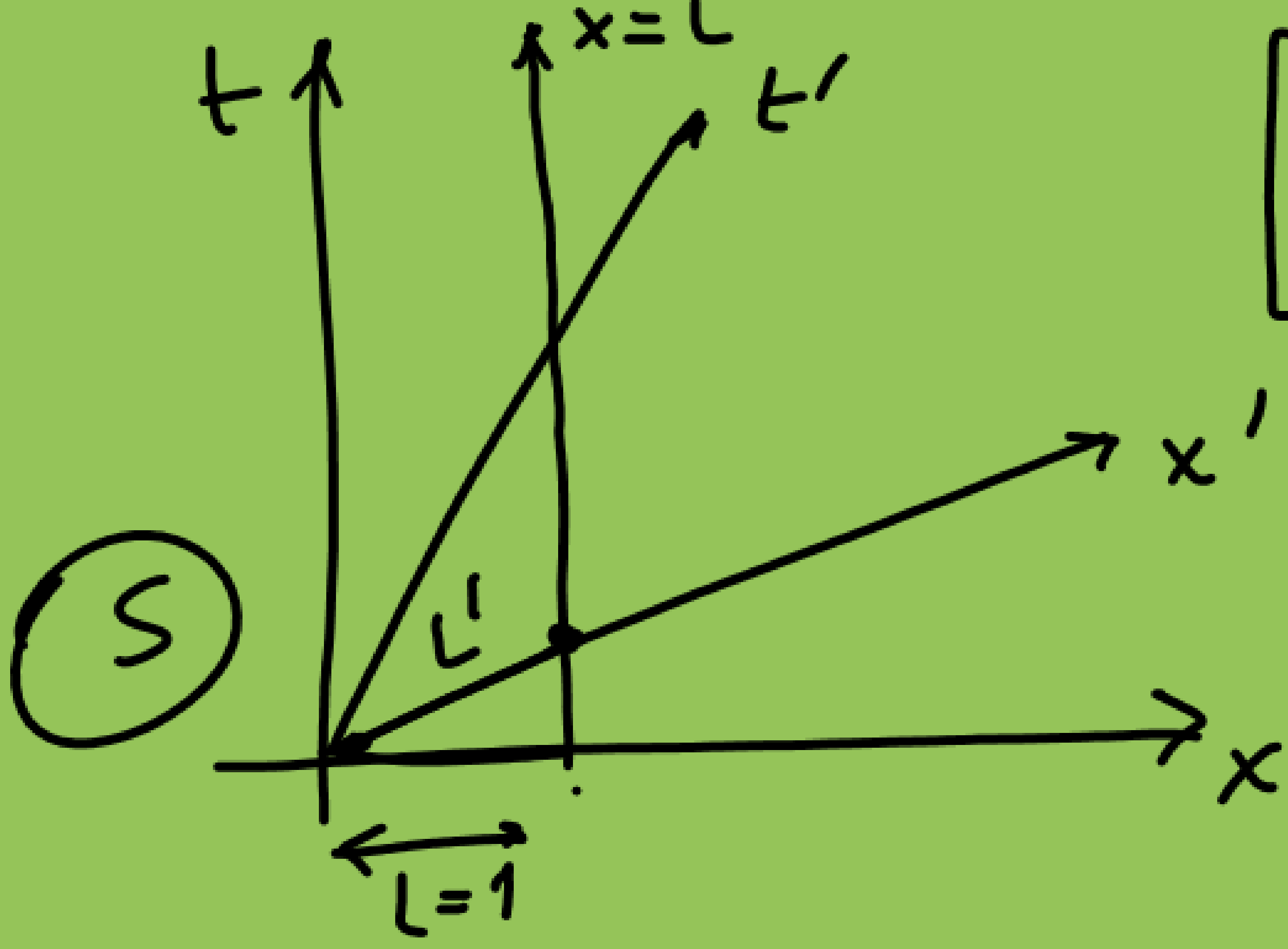
$$\boxed{ct' = \gamma\left(ct - \frac{v}{c}x\right)}$$

$$x' = f(x, t)$$
$$t' = g(x, t)$$

$$x_1' = \gamma(x_1 - vt_1)$$
$$t_1' = \gamma(t_1 - vx_1)$$

$$x_2' = \gamma(x_2 - vt_2)$$
$$x_2' - x_1' = \gamma((x_2 - x_1) - v(t_2 - t_1))$$
$$\Delta x' = \gamma(\Delta x - v\Delta t)$$

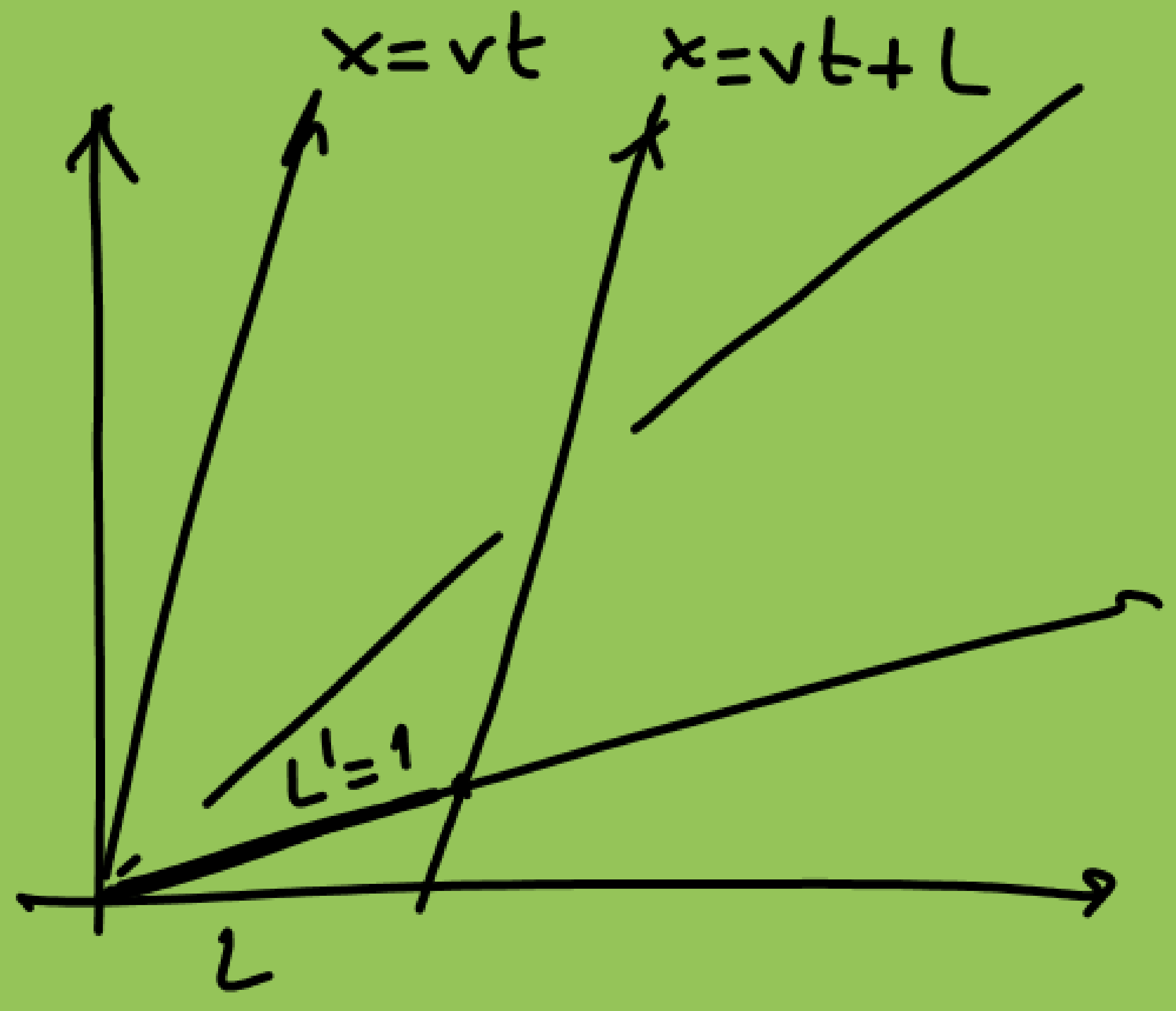
CONTRACCIÓN ESPACIAL



$$\begin{cases} \Delta t' = 0 \\ \Delta t' = \gamma(\Delta t - v\Delta x) \end{cases}$$

$$\Delta t = v\Delta x$$
$$\Delta x' = \gamma(\Delta x - v\Delta t)$$
$$\underbrace{\Delta x'}_{L'} = \gamma(\Delta x - v(v\Delta x))$$
$$= \gamma\Delta x(1 - v^2)$$
$$= \underbrace{\Delta x}_{L}\sqrt{1 - v^2} \qquad \gamma = \frac{1}{\sqrt{1 - v^2}}$$

$$\boxed{L' = \sqrt{1 - v^2}\, L}$$
$$L' = \frac{L}{\gamma}$$
$$\boxed{L' < L}$$



$$\underline{\Delta t = 0}$$

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

$$\Delta t' = -v\Delta x'$$

$$\underbrace{\Delta x}_{L} = \gamma(\Delta x' + v\Delta t')$$

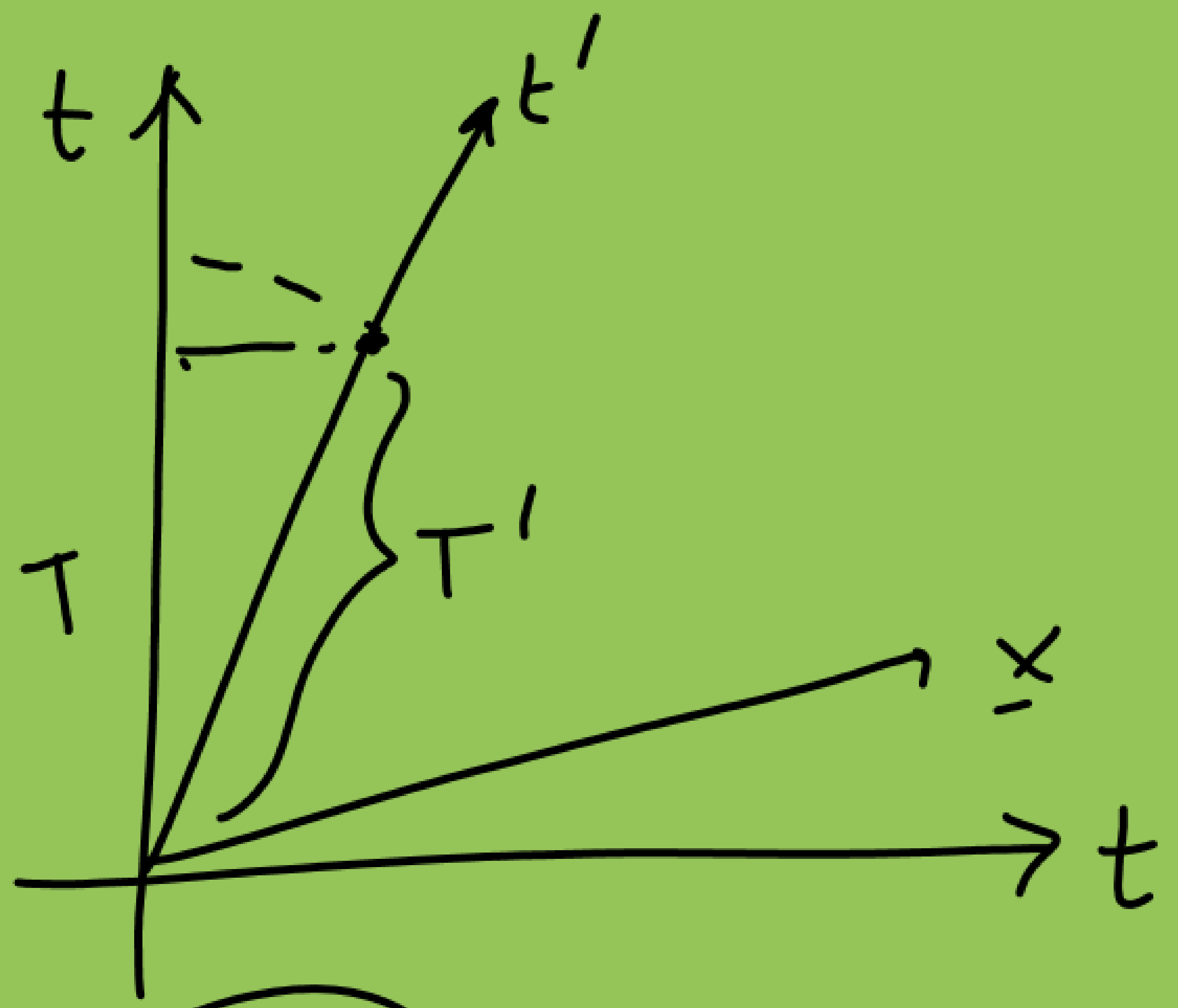
$$\Delta x = \gamma(\Delta x' - v^2\Delta x')$$

$$\Delta x = \Delta x' \underbrace{\gamma(1-v^2)}_{\sqrt{1-v^2}} \longrightarrow \Delta x = \sqrt{1-v^2}\,\Delta x'$$

$$\boxed{L = \underbrace{\sqrt{1-v^2}}_{<1}\, L'}$$

$$L < L'$$

DILATACIÓN TEMPORAL



$T < T'$

$$\Delta t = \gamma(\Delta t' + v\cancel{\Delta x'})$$
0.

$$\Delta t = \gamma \Delta t'$$

$$T = \gamma T' \rightarrow \boxed{T > T'}$$

$$\gamma > 1$$

$$\boxed{T' > T}$$

$$\Delta t' = \gamma(\Delta t + \cancel{v\Delta x})$$
0.

$$T' = \gamma T$$

$$\cancel{d(x,t) = \sqrt{x^2 + t^2} = \sqrt{\Delta x^2 + \Delta t^2}}$$

Dilatación temporal.