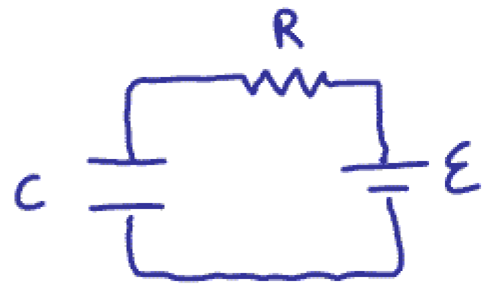
Physics 142 - October 11, 2005
Relativity

Exam Results
Troubleshooting guide

Last Time -

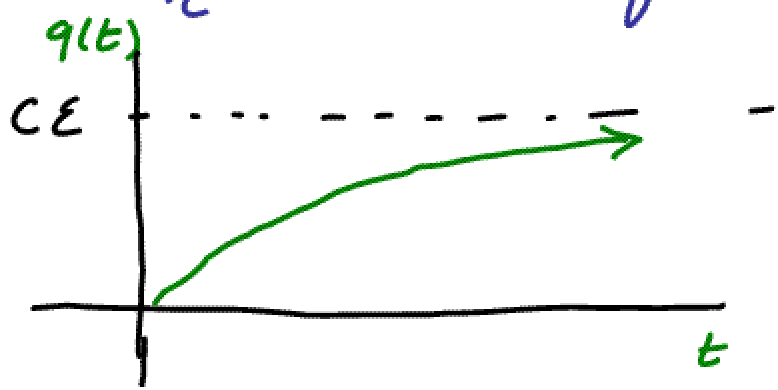
RC circuits

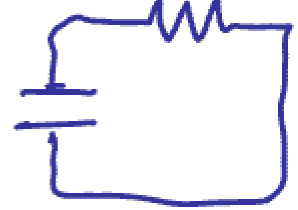


$$\mathcal{E} - iR - q/C = 0$$

$$\mathcal{E} - \frac{dq}{dt}R - q/C = 0 \implies q(t) = C\mathcal{E}\left(1 - e^{-t/RC}\right)$$

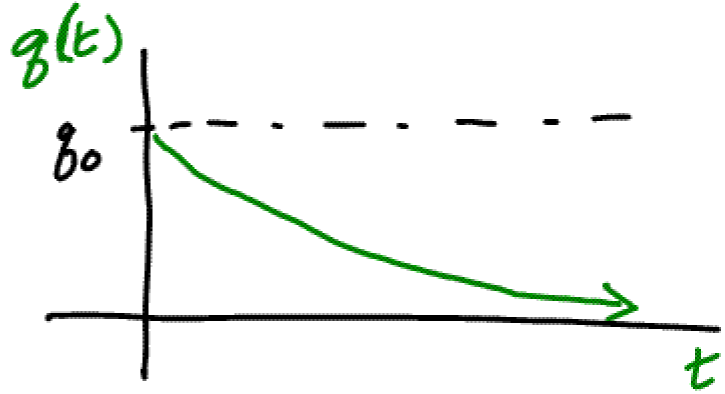
charging



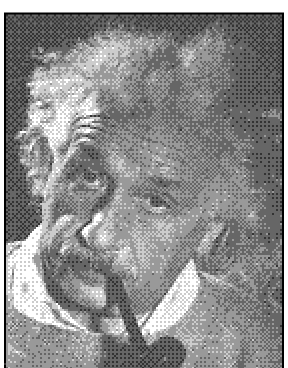


discharging

$$\frac{dq}{dt}R = -\frac{q}{c} \Rightarrow q(t) = q_0 e^{-t/RC}$$



Introduction to the Special theory of Relativity



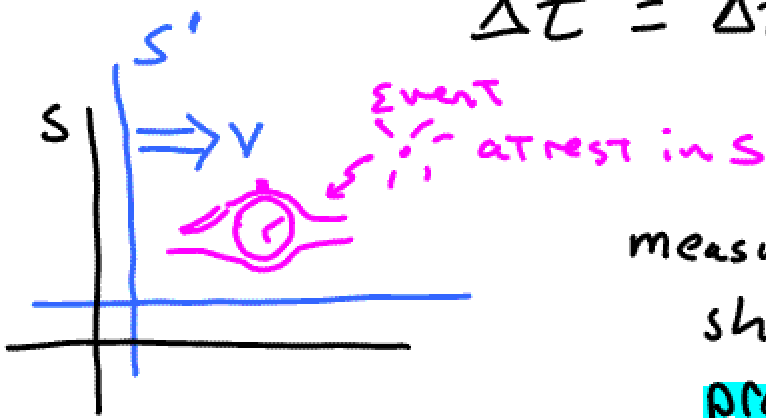
1. Physics is the same in all inertial Reference frames

No Acceleration
Moving at const. V

② Velocity of light (in vacuum) is observed to be the same in all inertial reference frames (c)

Time dilation

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

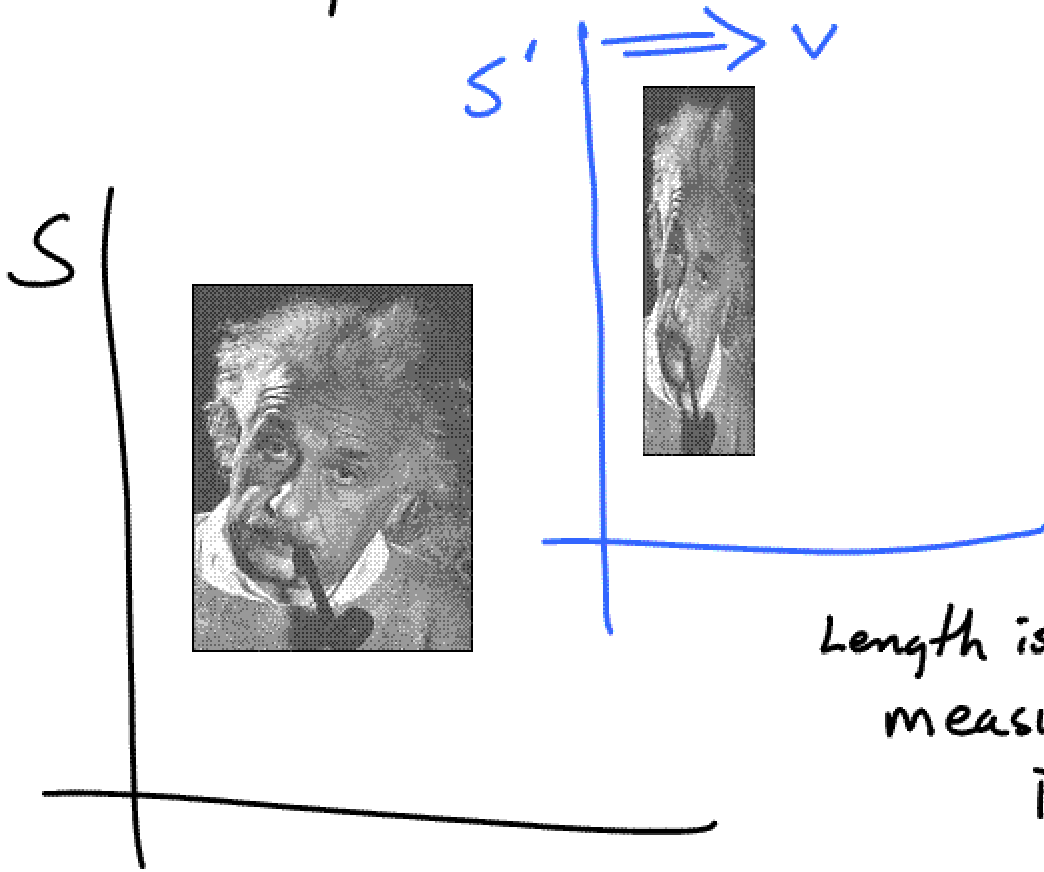


$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} > 1$$

measured time is shortest in proper frame of reference

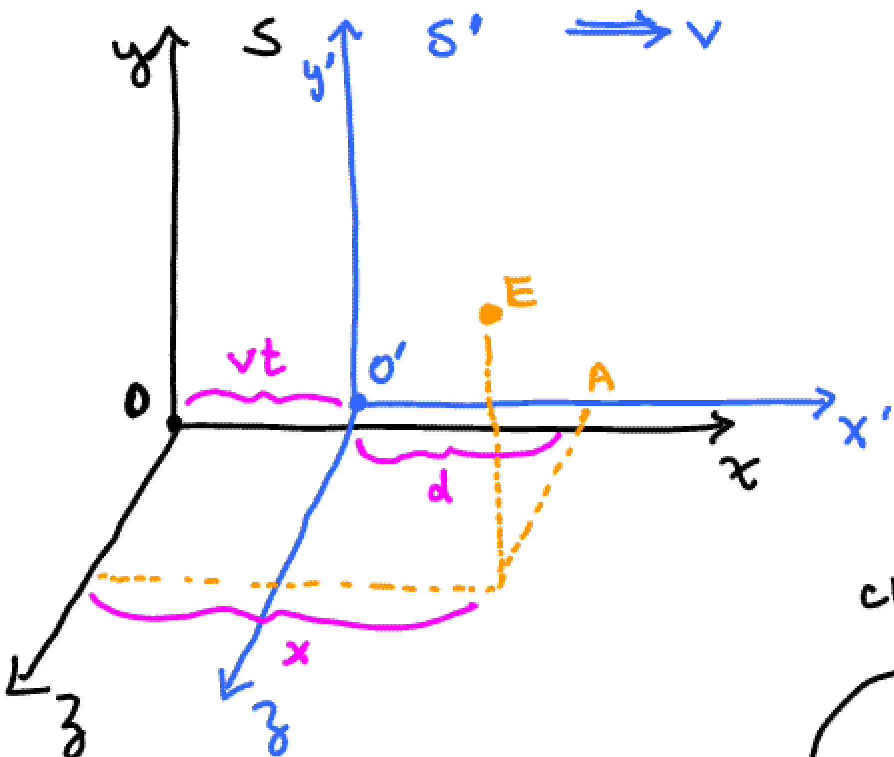
frame where Event is at Rest

Length Contraction



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

Length is greatest when measured in Proper Frame of Reference

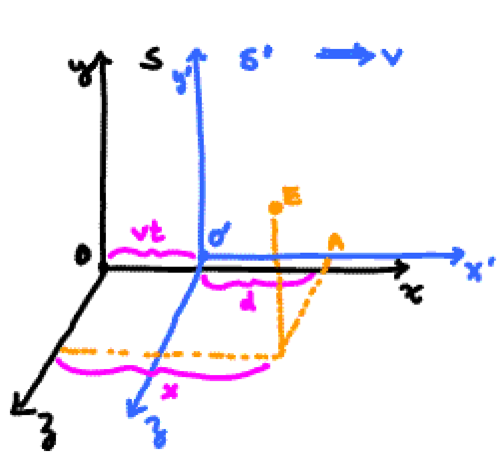


at $t=0$, $t'=0$
two systems
overlap
$O=O'$

classical physics:

Galilean Transformations

$$\begin{cases} x' = d = x - vt \\ y' = y \\ z' = z \\ t' = t \end{cases}$$



$$d = \frac{x'}{\gamma}$$

$x' = \gamma d$ as meas in S' system

$$d = x - vt$$

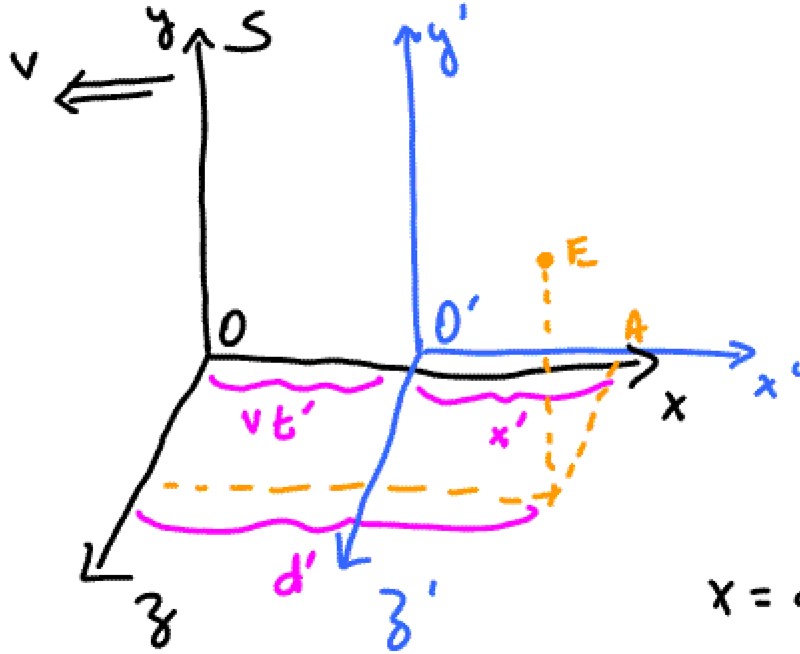
$$\frac{x'}{\gamma} = x - vt$$

Relativistic transformations

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

Lorentz Transformations

$$x = \gamma(x' + vt)$$
$$y = y'$$
$$z = z'$$
$$t = \gamma\left(t' + \frac{v}{c^2}x'\right)$$



Gallilean trans.

$$x' = d' - vt'$$

$$d' = x \qquad t' = t$$

$$x' = x - vt$$

x = dist from O → A in S

$$d' = \frac{x}{\gamma}$$

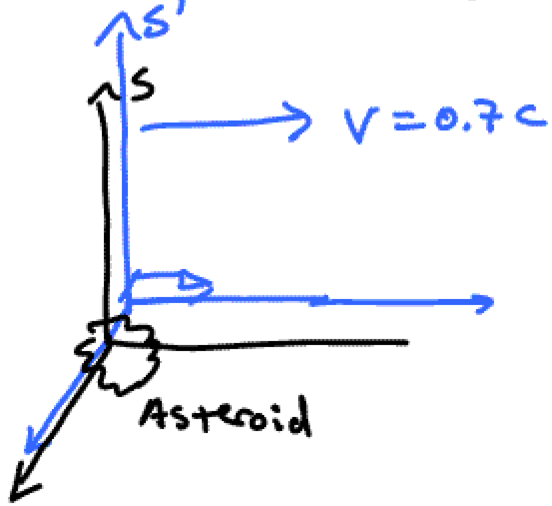
$$x' = d' - vt'$$

$$x' = \frac{x}{\gamma} - vt' \qquad x = \gamma(x' + vt')$$

$x = \gamma(x' + vt')$ sub in $x' = \gamma(x - vt)$

$x = \gamma[\gamma(x - vt) + vt']$ Algebra

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



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

$$\gamma = 1.40$$

Event 1 $t=0$, $t'=0$ origins coincide

Spaceship passes by Asteroid

event 2 Laser flashes on S at $x = 3$ km, $t = 5\mu s$

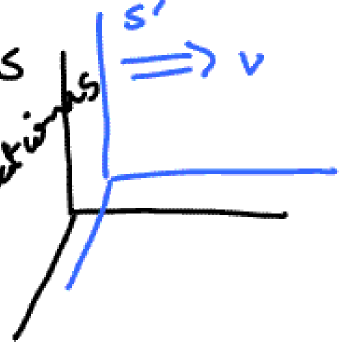
what does evt 2 look like in frame S'

$$x_2' = \gamma(x - vt) = 1.4\left[3 - (.7)\, 3\times10^5 \frac{km}{s}\, 5\times10^{-6} s\right]$$

$$= 2.73 \text{ km}$$

$$t_2' = \gamma\left(t - \frac{v}{c^2}x\right) = 1.4\left[5\times10^{-6} s - \frac{.7 \quad 3.0\,km}{3\times10^5\, km/s}\right] = -2.8\mu s$$

velocity transformations



$\vec{U}$ = velocity in S

in S $\quad U_x = \frac{dx}{dt}$

$U_y = dy/dt$

$U_z = dz/dt$

in S'

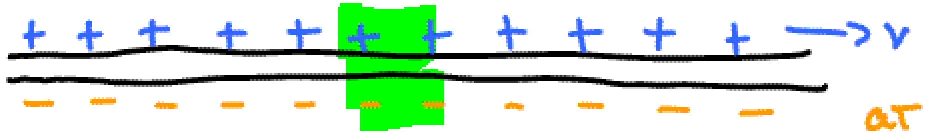
$$U_x' = \frac{dx'}{dt'} = \frac{\gamma(dx - v\,dt)}{\gamma\left(dt - \frac{v}{c^2}dx\right)} = \frac{\gamma\left(\overbrace{\frac{dx}{dt}}^{U_x} - v\right)}{\gamma\left(1 - \frac{v}{c^2}\overbrace{\frac{dx}{dt}}^{u_x}\right)}$$

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

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

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

2 wires



λ_+

at rest λ_-

$\bullet\, q_0$ at rest

$\lambda_- = \lambda_+$

Electrostatic force on q^0 = 0

Switch to frame of reference where q_0 is moving

$\bullet \xrightarrow{u} q_0$

Now $\lambda_- \neq \lambda_+$ – so there is now a force

Force or Not? depends on frame of reference

Resolution of this lies in Relativistic theory of E+M