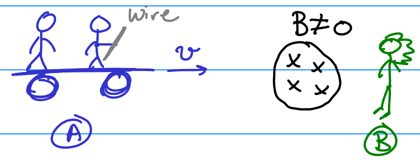
Relativity

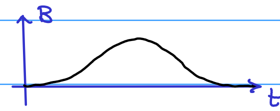
4/25/07

But consider a charge moving at velocity v: (don't exactly know the setup here)



A: sees $\vec{\nabla} \times \vec{E} = -\partial \vec{B} / \partial t$

B: Sees $\vec{F} = q\vec{v} \times \vec{B}$



(Better hope these forces are the same)

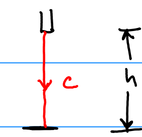
Principles of Relativity:

① "The laws of physics are the same for all inertial frames of reference" ~Galileo

② The speed of light is the same to all inertial observers, regardless to their relative motion

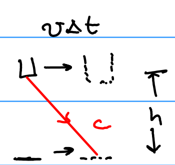
Let's apply the second to the concept of time...

A sees:



Light travels a distance h in time $\Delta t_A = \frac{h}{c}$

B sees:



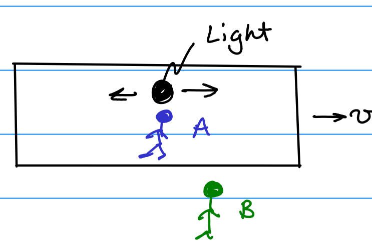
Light travels a distance $\sqrt{v^2 \Delta t_B^2 + h^2}$ in time $\Delta t_B = \frac{1}{c}\sqrt{v^2 \Delta t_B^2 + h^2}$

$\Rightarrow \Delta t_B^2 = \frac{v^2}{c^2}\Delta t_B^2 + \Delta t_A^2 \qquad \Rightarrow \Delta t_B^2 = \Delta t_A^2 \frac{1}{\sqrt{1 - v^2/c^2}}$

So we see a difference in the passage of time ... this can be verified experimentally with muons or atomic clocks on airplanes. Also, remember the gedanken experiment of the Twin Paradox. Think about sending signals once every 5 minutes!

Simultaneity:

4/27/07

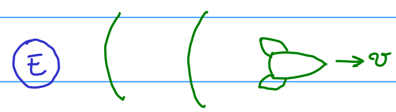


Say you have a source of light in a moving boxcar. Someone in the boxcar sees the light hit each wall at the same time (or if he's not in the middle can correct for that simultaneity).

Observer B sees the boxcar moving to the right, and as the speed of light is constant, the light to the left travels less distance and thus the light hits the left side of the car first.

<u>Twin Paradox</u>: Say rocket traveling at $v = c/2$ for 120 minutes

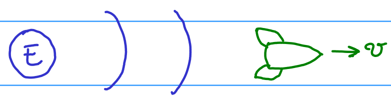
Case 1: Rocket sends out flashes once every 6 min



Earth sees 10 flashes at 12 min intervals [while rocket recedes], and 10 flashes at 3 min intervals [while rocket returns]

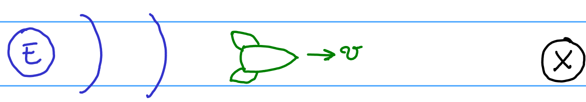
So Earth sees $\Delta t = 150$ min, and rocket sees $\Delta t = 120$ min.

Case 2: Earth sends out flashes at 3 min intervals



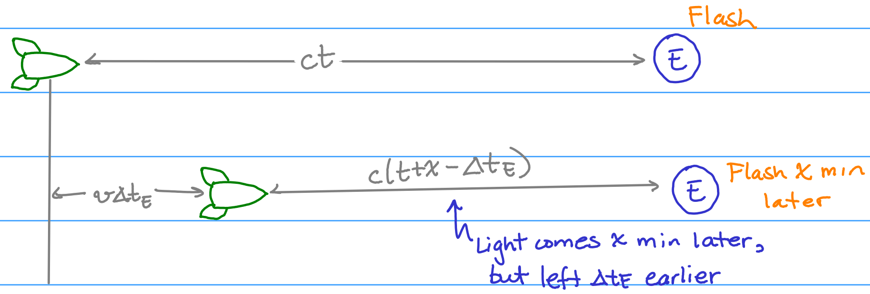
The rocket is barreling away, increasing the distance each light pulse needs to travel (but it's still going at c). So rocket sees pulses once every 6 minutes.

Case 4: Rocket sends out flash to planet X when it sees Earth's flash



X sees Earth's pulses every 3 minutes, and thus the rocket's pulses every 3 minutes. As the rocket receives the Earth's pulses every 6 minutes, it sends one out every 6 minutes, but X gets those every 3 minutes because the rocket approaches it.

Now let's relate velocities and flash rates (Sorensen made a boob joke ...) 4/30/07



$$ct = c(t+x-\Delta t_E) + v\Delta t_E \Rightarrow 0 = xc - \Delta t_E c + v\Delta t_E \Rightarrow \Delta t_E = \frac{x}{1-v/c} \text{ (minutes)}$$

$\gamma \Delta t_{ss} = \Delta t_E$. Want $\frac{\Delta t_{ss}}{\Delta t_E} = f$. Let $\beta = v/c$

$$\Rightarrow \frac{\Delta t_{ss}}{\sqrt{1-\beta^2}} = \frac{\Delta t_E}{1-\beta} \Rightarrow f^2 = \frac{1-\beta^2}{(1-\beta)^2} = \frac{1+\beta}{1-\beta}$$

$$\Rightarrow \beta(1+f^2) = f^2 - 1 \Rightarrow \beta = \frac{f^2-1}{f^2+1}$$

So for a factor of 2 difference, $v = \frac{3}{5}c$