# Today

Modern Day 7

I Last time

II The Spacetime picture for two frames

III Relativity of Simultaneity

IV Time dilation

V Length Contraction

I. Studied relativistic collisions: 

- Conservation of E and $\vec{p}$ hold in relativity provided you use their relativistic definitions.
- Made several suggestions for doing calculations:

Suggestion 0: Work with E and $\vec{p}$, not with $\vec{v}$.

Suggestion 1: Use

$$E^2 - \vec{p}^2 c^2 = m^2 c^4$$

to get E given $\vec{p}$ and vice versa.

Suggestion 2: To get $\vec{v}$ given E and $\vec{p}$ use,

$$\vec{v} = \frac{\vec{p} c^2}{E}.$$

Now we'll return to spacetime diagrams to review and summarize all the relativity we've learned.

II Q: Can I draw another, moving observer's frame on the same spacetime diagram? Yes!

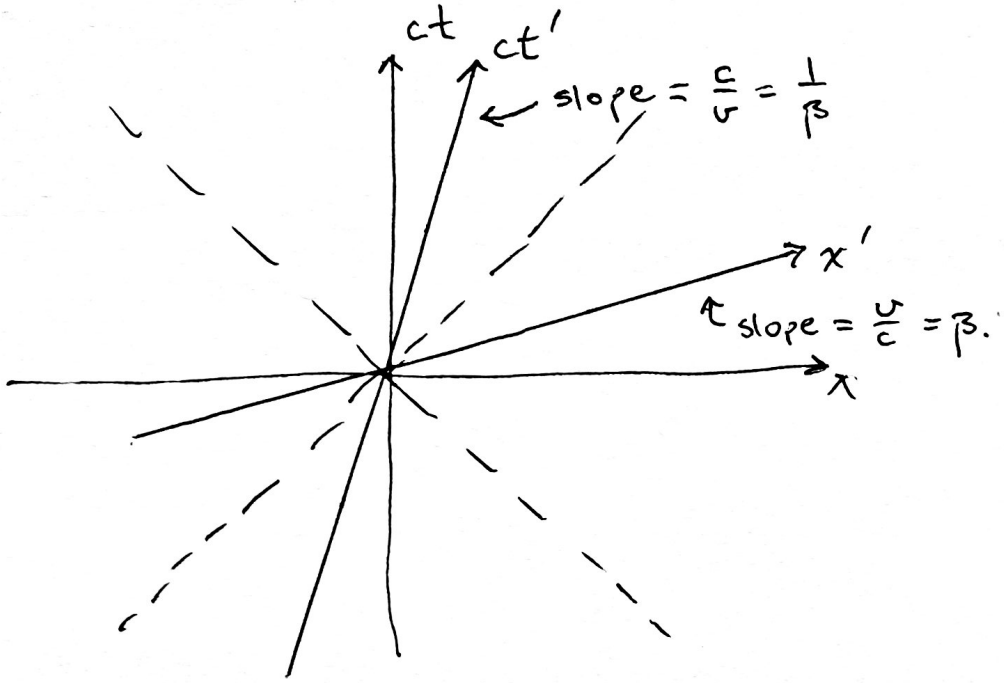
Use the Lorentz transformations

$$ct' = \gamma(ct - \beta x), \quad \beta = \frac{v}{c}$$
$$x' = \gamma(x - \beta ct).$$

Time axis for the primed frame is at $x' = 0$, so,

$$0 = \gamma(x - \beta ct) \Rightarrow ct = \frac{1}{\beta} x = \frac{c}{v} x$$

(slope $\downarrow$; $ct'$ axis)





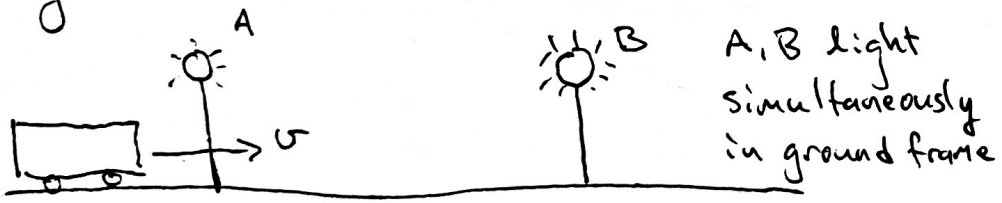

Similarly, the x'-axis is the locus of points for which ct' = 0 or

$$0 = \gamma(ct - \beta x) \Rightarrow ct = \beta x$$

(slope)

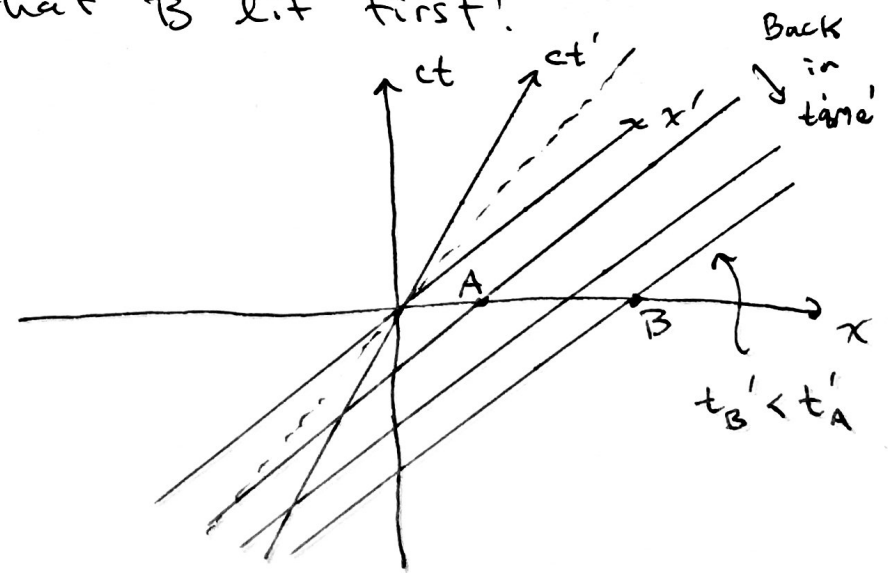
Because these slopes are inverses of one another, the axes are equally displaced towards the light cone.

III This gives us a graphical way to understand HW 1, prob. 2:

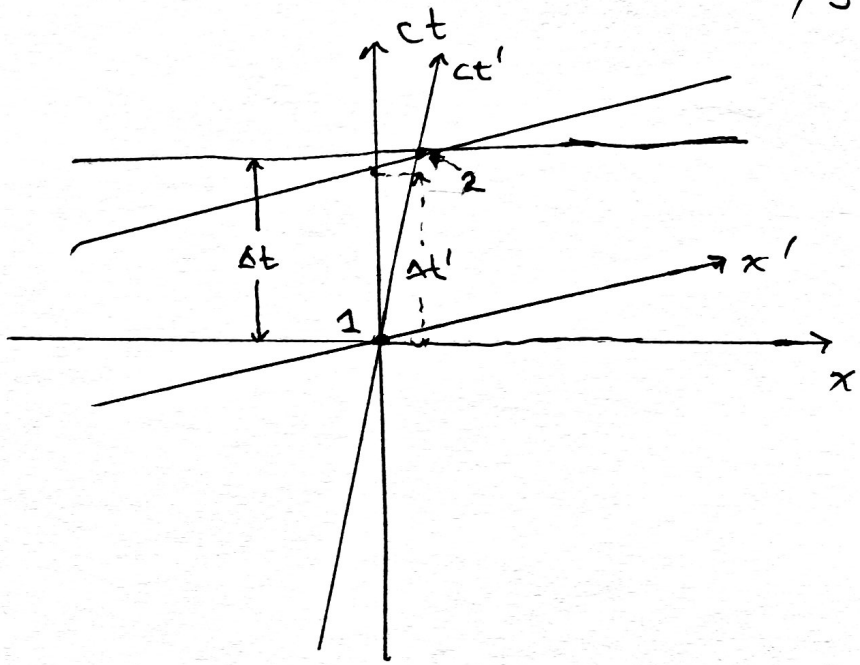



Does A or B light first according to observers on the train?

The x'-axis consists of all events that happened at t' = 0. Similarly, any line parallel to the x'-axis consists of a set of events simultaneous in the S' frame. This allows us to conclude that B lit first!



IV Take event 1 at the origin and event 2 as indicated. All events simultaneous with 2 in the S' frame are along the slanted line, while all events simultaneous with 2 in the S frame are along the horizontal line, which crosses the ct axis above the slanted line. Hence, the time elapsed in S is longer than the time elapsed in S' $\rightsquigarrow$ $\Delta t = \gamma \Delta t'$.




V The key to understanding length contraction is to notice that what we mean by the length of a train (or any object) is the distance btwn its two ends measured at the <u>same time</u>. (otherwise, if the object were moving, then we could get the wrong length.) But, of course, we've argued simultaneity is a relative notion.