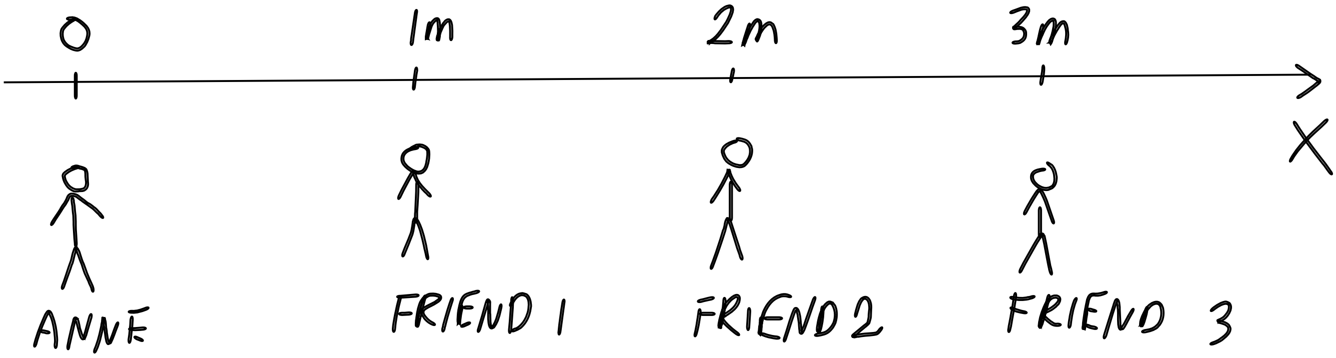
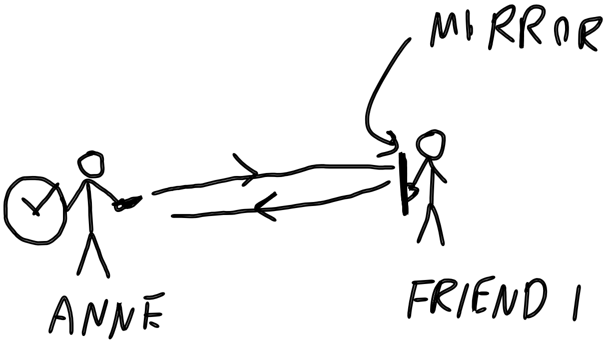
Principle of relativity (again):
Light travels with the same speed, c, in all inertial reference frames

We will trust nothing in trying to figure out how this can work; we will use logic and statements about actual measurable things only. First, we are going to talk about building a frame of reference (the coordinate system).

Anne has recruited some of her friends to help her to distance and time measurements. She lines up her friends in a row like this:



She makes sure her friends are equally spaced by sending light pulses to them and having the pulses bounced back to her.



Anne times the pulse and makes sure it takes exactly 2X(1m)/c seconds to go there and back

Once her friends are placed, they stay put. Now Anne needs to synch their clocks. She wants all the clocks to show 12:00 at the same time. At 12:00 by her clock she sends out a timing pulse.

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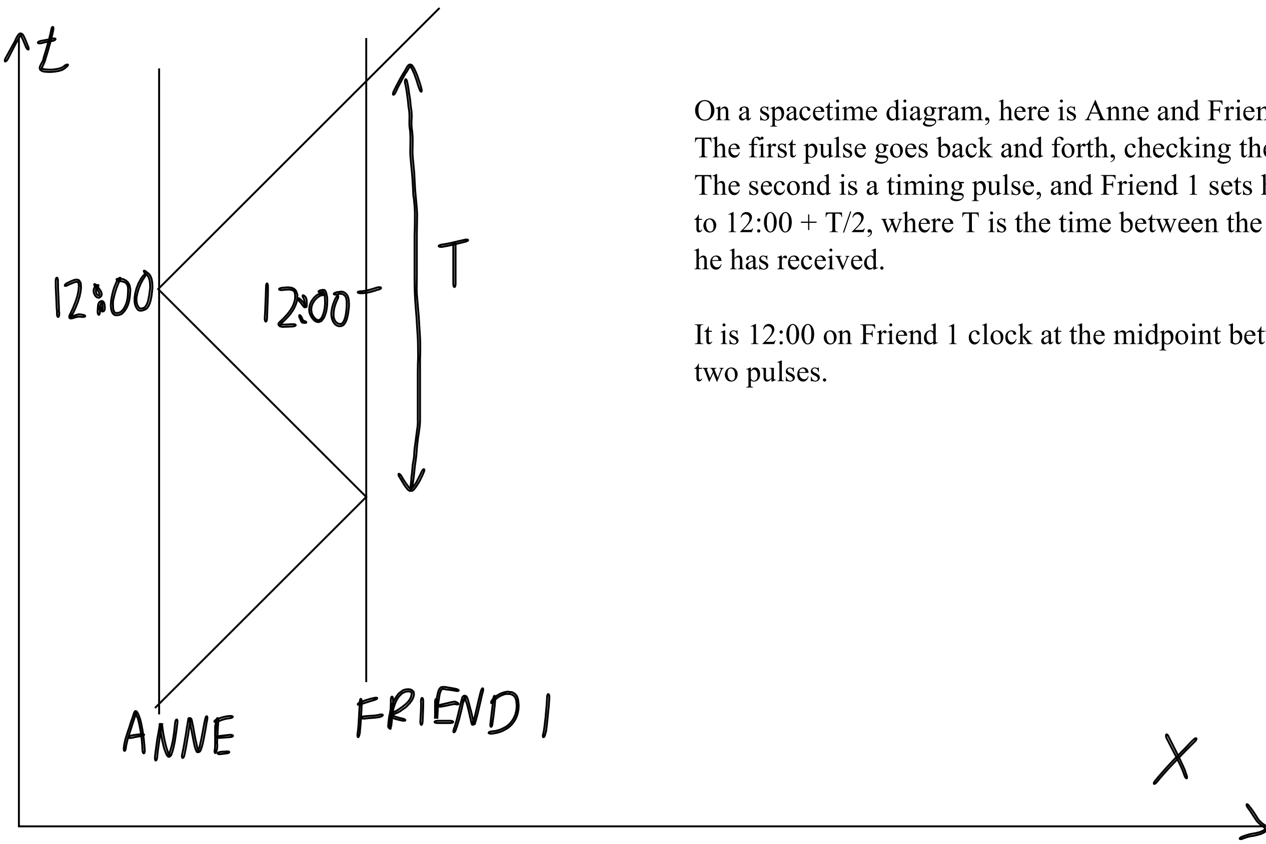
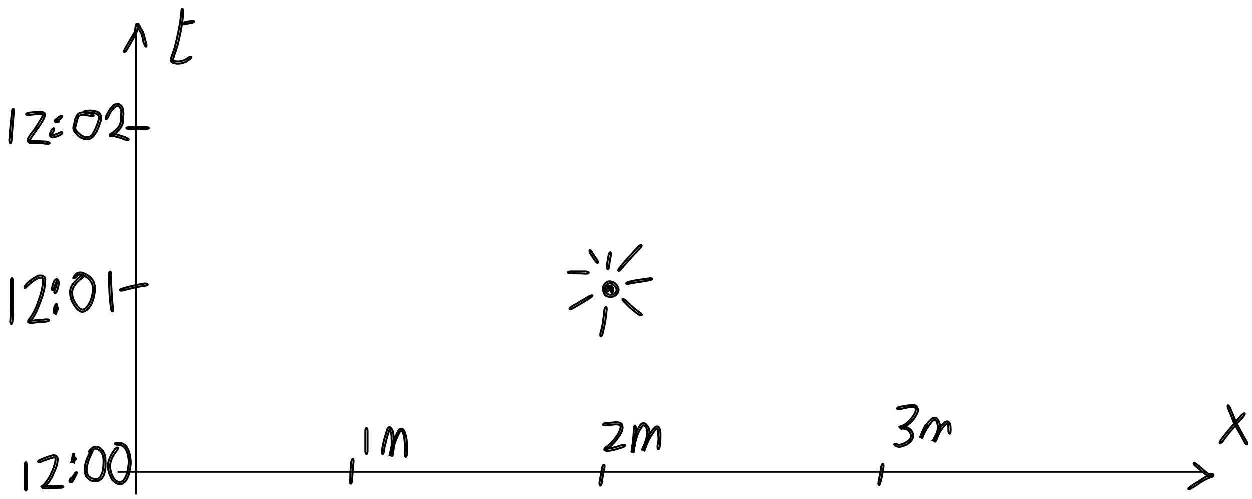


On a spacetime diagram, here is Anne and Friend 1.
The first pulse goes back and forth, checking the distance.
The second is a timing pulse, and Friend 1 sets his clock to 12:00 + T/2, where T is the time between the two pulses he has received.

It is 12:00 on Friend 1 clock at the midpoint between the two pulses.

With this done, Anne has build herself a coordinate system. She has observers placed everywhere, with synchonized clocks. If an event (say, an explosion) happens at x=2, Friend 2 can measure when it happens. No 'town-hall' clock. Every event is recorded by the clock 'on site'.



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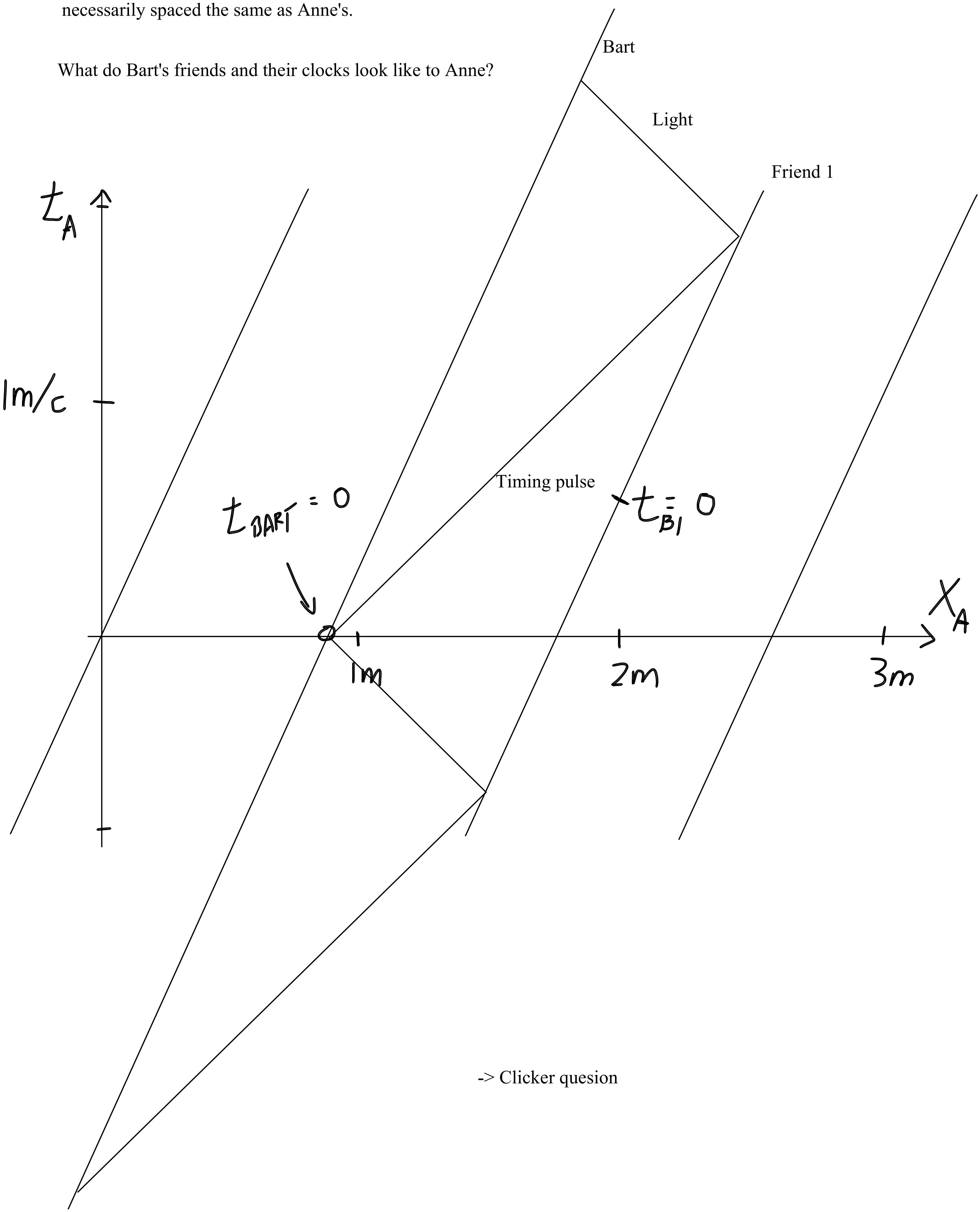
Incidentaly, Anne lined up her friends along the railway tracks.
Bart does exactly the same thing himself, with his friends, on a train going with speed v. His friends are not necessarily spaced the same as Anne's.

What do Bart's friends and their clocks look like to Anne?



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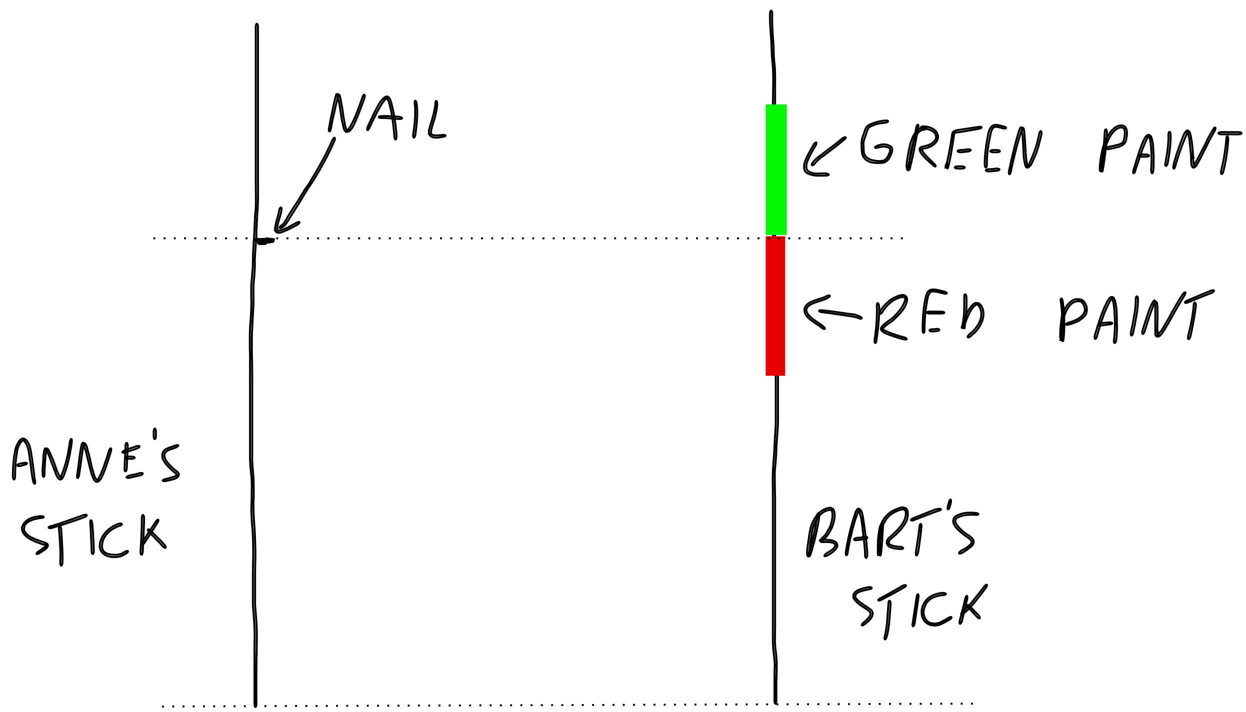
Distances perpendicular to the directior of motion

Anne and Bart get two long sticks. Two meters from one end of the stick, Anne puts in a nail so that its point stick out. Bart paints a part of his stick green and a part red, with the line between the two at 2 m:



Bart takes his stick on the train. They both hold the sticks vertical, with the bottom's aligned. As the sticks pass, the nail scratches the paint.

Since they can later get together and compare, it is a logical fallacy to predict that, for example, there will be green paint on the nail and a scratch in the red paint region. Anne's and Bart's observiations must match on that.

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Conclusion: distances in directions perpendiculat to the direction of motion are not affected.