Time Examined

Day 2

I The pledge: principle of relativity

II The turn: universal speed of light

III The prestige: relativity of simultaneity

I Einstein was a great magician. He turned ordinary observations about the world into extraordinary insights that change how we think about it.

The principle of relativity:
No (physical) phenomena have properties corresponding to the concept of absolute rest.

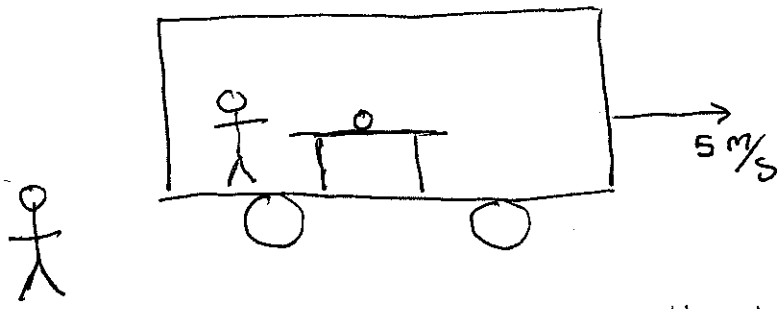
This is an old idea — Galileo said it too. But, it needs unpacking.

In a uniformly moving train car, experiments are just the same as at rest.

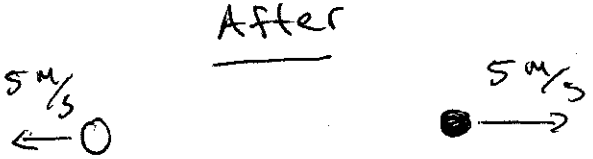
This allows us to connect the results of experiments as seen by two different observers just by taking into account their relative motion.

A wildly simple experiment: place a ball on a table and do nothing to it. Result: it just sits there.

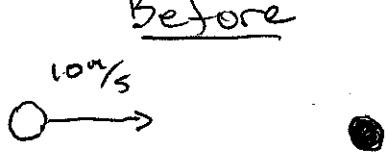
Now, repeat this experiment on a train moving



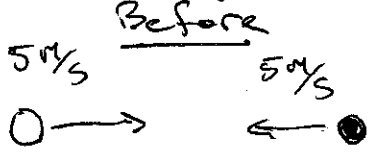
Relativity tells us that the ball stays at rest in the train. Hence, according to an observer on the ground the ball moves at 5 m/s to the right.



What can we conclude about an experiment where we launch a bouncy ball at one that's at rest?



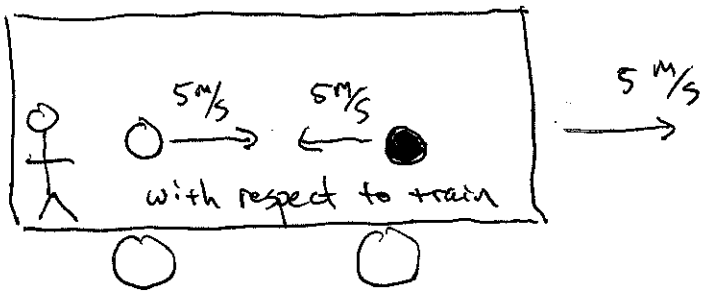
Bouncy balls have the property that if you send them at each other with equal and opposite speeds, they bounce out with equal and opposite speeds



Predict the after result naively, that is, without any argumentation.

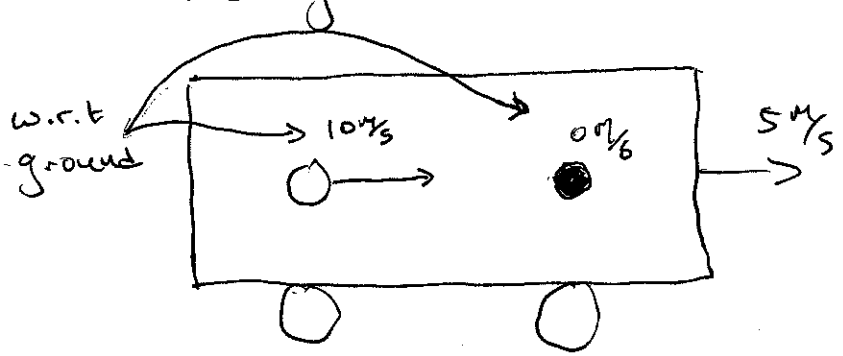
How can we figure it out?

Try in a train



「 with respect to = w.r.t. 」

From the ground this looks like



We can summarize in a table

	Before	After
Train	5 m/s, 5 m/s	5 m/s, 5 m/s
Ground	10 m/s	10 m/s

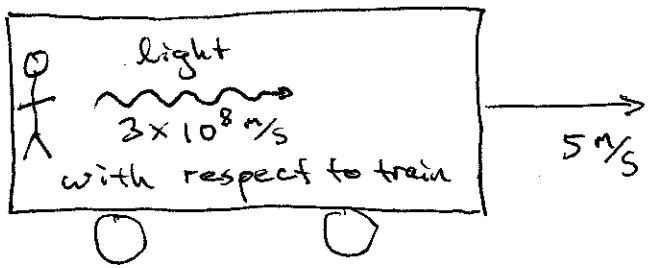
The results of the experiments that we are talking about are not tied to one particular observer, but shared results of all observers in the same state of motion. We refer to this state of motion as a reference frame and talk about the "train frame" or the "ground frame".

All of the motion gets transferred to white ball!

Sticky balls, like clay, behave differently: when they collide with equal and opposite speeds they come to rest (and stick together).

	Before	After
Train	5 m/s, 5 m/s	
Ground	16 m/s	5 m/s

II Much like bouncy balls and sticky balls behave differently, Einstein postulated that light has a unique behavior: the speed of light (3×10^8 m/s) is the same <u>regardless</u> (of the motion of its source, or the observer).



Also, 3×10^8 m/s ! (w.r.t. ground)

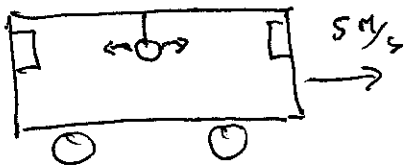
This is a daring hypothesis with dramatic consequences. Let's derive one of these.

(A) In what order do the two detectors fire according to an observer on the train?

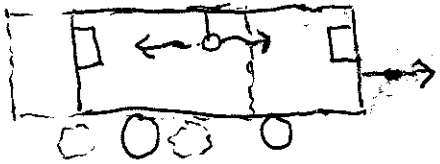
R & F fire simultaneously

(B) According to an observer on the ground?

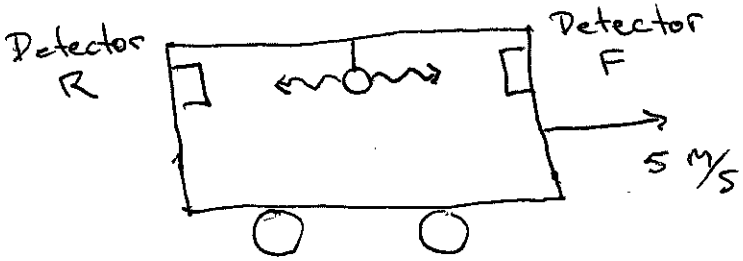
Before



Later



III Consider a light bulb hung from the center of a train car. Place light detectors on the front and rear walls of the car



Ground observers find that R fires before F!

Conclusion: Two events simultaneous in one reference frame, may not be in another reference frame!

Simultaneity depends on your state of motion.