

SPECIAL RELATIVITY

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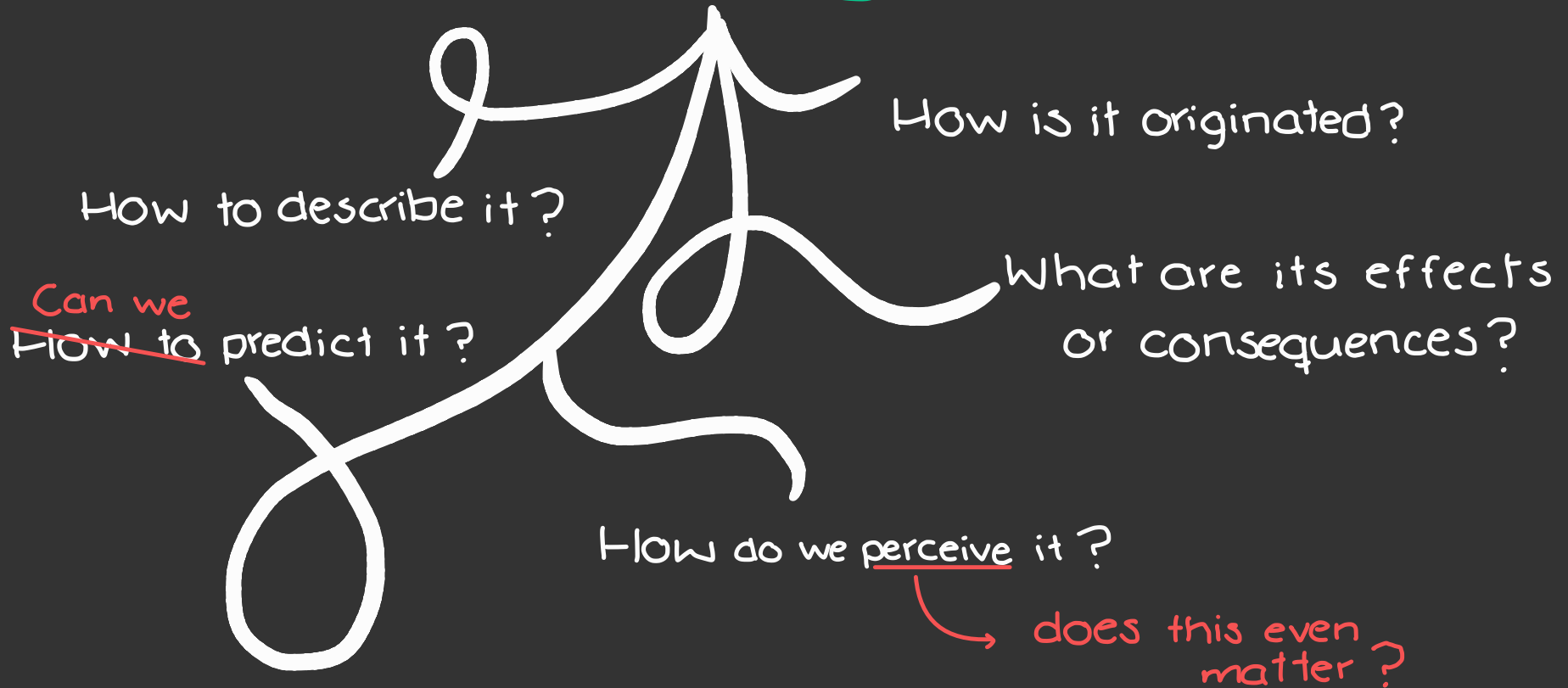
obsession
What is the main ~~goal~~
of PHYSICS ?

TRAINS!



Well, actually...

MOTION!



Back to trains, let's conduct a

THOUGHT EXPERIMENT

You wake up in a futuristic train with no windows and no communication with the outer world.

- Q. Is it possible to know if the train is actually moving?
- > Can you propose an experiment whose results may answer that question?
- < If the train is moving at **constant speed**, there is no way to determine (from the inside) if it is actually moving...

UNLESS → it changes its speed in the course of the journey

ACCELERATION!

DISCUSSION { Propose an experiment that let you measure (or notice) the acceleration of the train while being still inside of it. }

Importance of ^{having a constant velocity}
inertial frames of reference

~> What are they?

~> A system with uniform translation (ie. constant velocity) → Wherever Newton's 1st law applies

~> Why are they important?

CANVAS

~> They let you define the ~~amphitheater~~ where the laws of physics can perform.

“All LAWS of PHYSICS are the same (and can be stated in their simplest form) in all inertial frames.”

- KHABY LAME

NOTICE

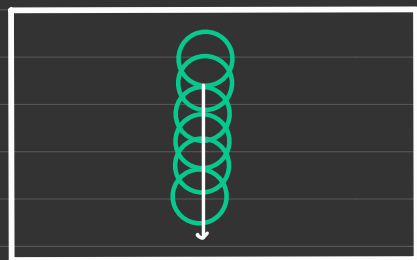
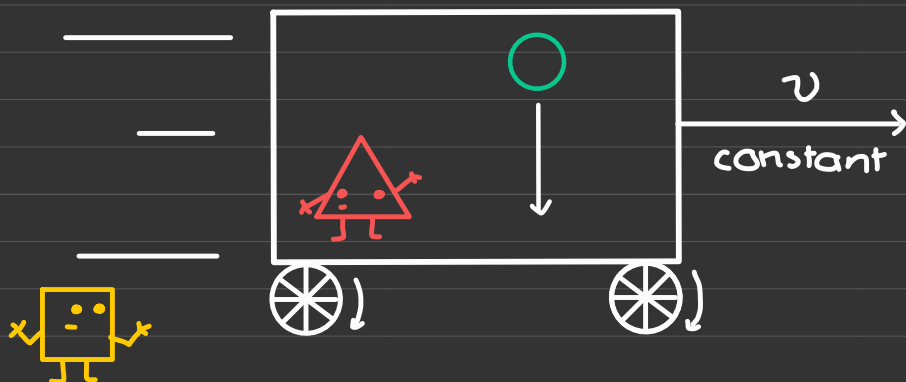
The concept of a constant velocity **interwines** in a SIMPLE and nice way two concepts:

TIME & SPACE

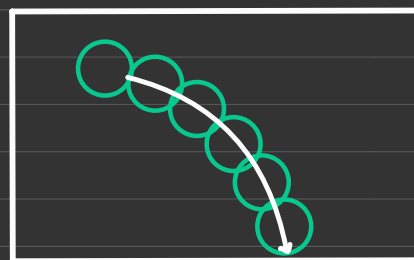
REAL LIFE EXPERIMENT

You are on a train with a fixed speed and let a ball fall. What is the trajectory of the ball?

It depends **who** are you asking the question!



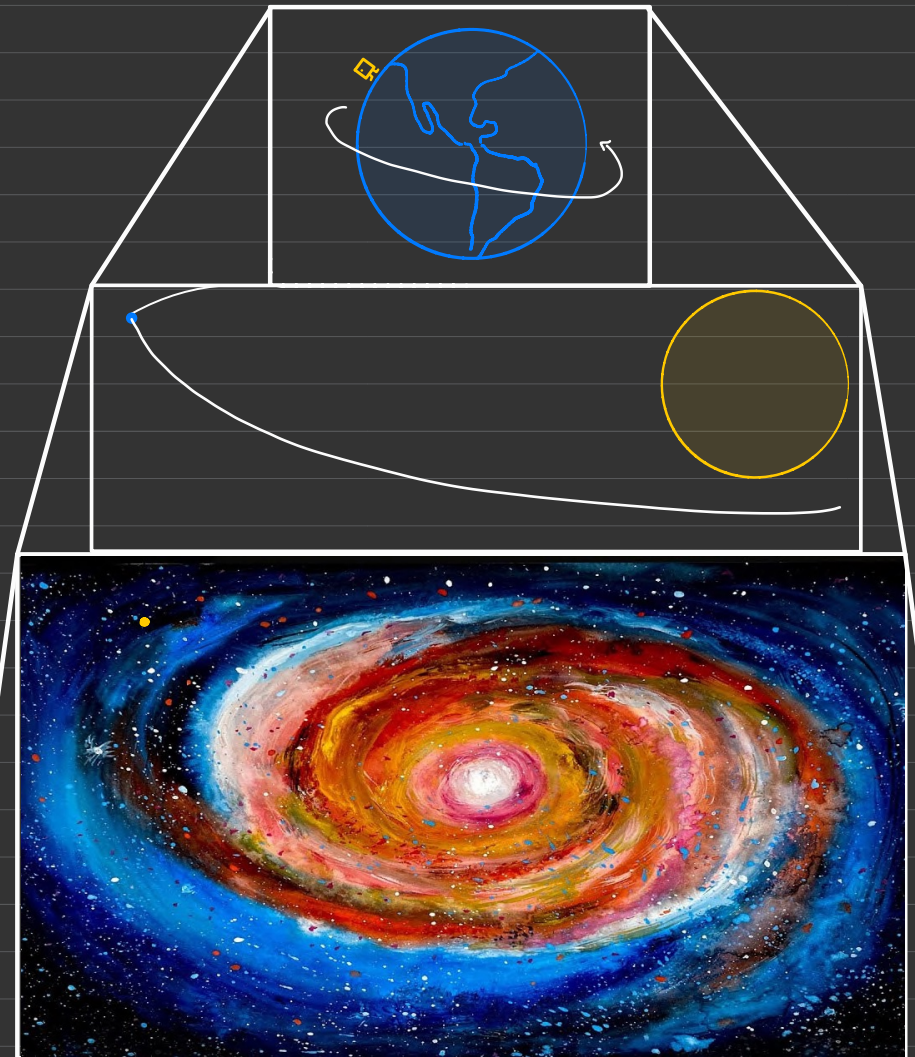
(for the triangle)
STRAIGHT LINE



(for the square)
PARABOLA

What is the *true* MOTION?

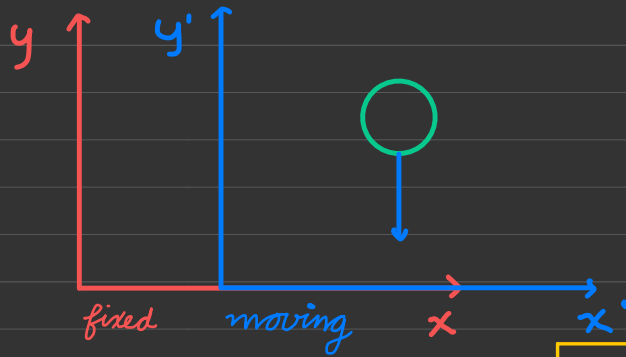
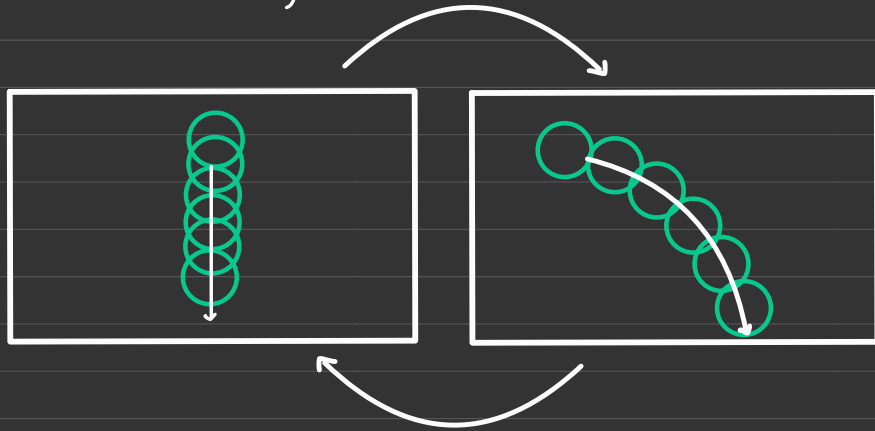
Which should be the preferential frame of reference?



Is it all relative then?

Ok, back to trains..

We must establish a way to translate what each observer is seeing from their own frame of reference

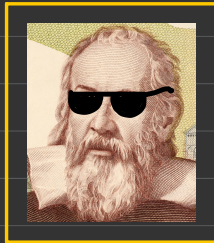


$$x' = x - vt$$

$$y' = y$$

What about time?

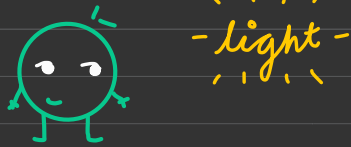
$$t' = t$$



"Galilean" transformations are the official translators between two inertial frames

Enlightenment

Let's talk about



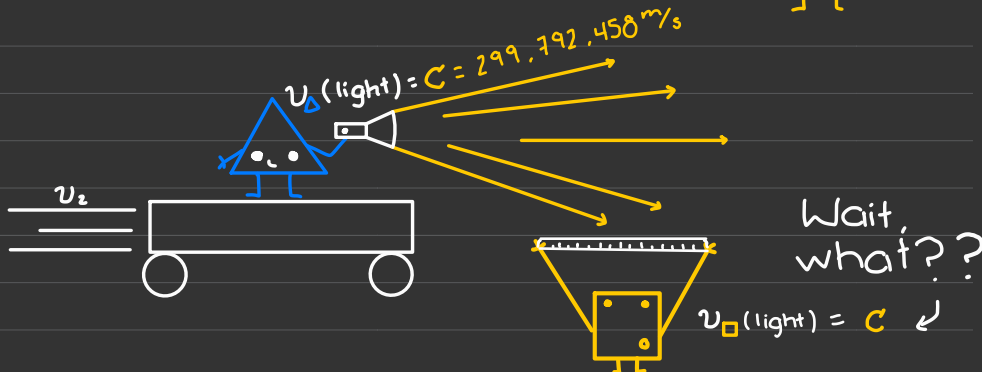
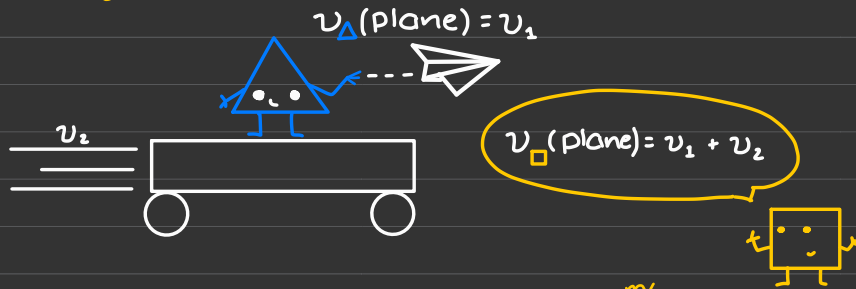
light

Yes!
What is it made of?
How is it created?
Is it a wave or a particle?



NEVERMIND!

Let's start throwing stuff from a moving wagon instead.



Well...

...the actual Michelson-Morley experiment was a little bit more intricate...

Michelson-Morley Experiment

ART. XXXVI.—On the Relative Motion of the Earth and the Luminiferous Ether; by ALBERT A. MICHELSON and EDWARD W. MORLEY.*

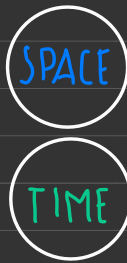
CONCLUSION

“The speed of light is the same for all observers, regardless of the frame of reference in which it is measured”

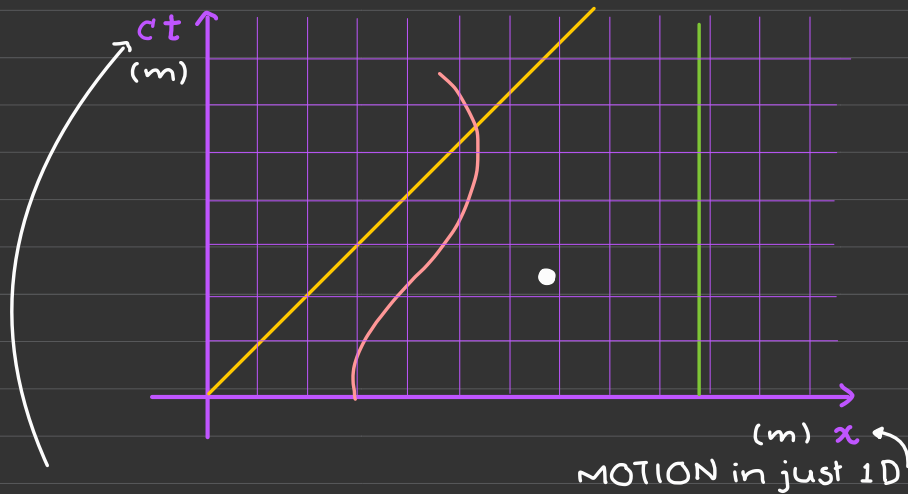
- CHARLI D'AMELIO

SPACETIME diagrams

We have seen that the fact of having a constant velocity lets us talk about SPACE and TIME as if they were the two sides of the same coin!



Let's explore the geometric implication of that!



What about the units?

As the speed of light is so fundamental, we can define new units, with respect to it!

For simplicity, let's define $c = 1$

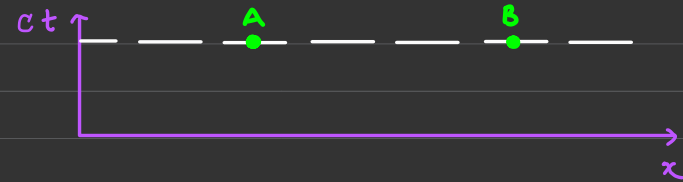
$$c \text{ 1seg} = 3 \times 10^8 \text{ m}$$

That is not something new



DEFINITIONS

- An event is a POINT in a SPACETIME diagram
- A curve may represent a «world line» of a particle. It encapsulates the info. of the motion of a particle.
- Two events are SIMULTANEOUS (from the t - x frame of reference) if they are located parallel to the x -axis



Q: What curve in the ST canvas would describe:

- A T-rex that remains at the same spot $x = \pi$ as time passes
- An octopus moving with constant speed $v = 0.5$
- Drake driving a car with constant acceleration

SOLUTION

Light $c = 1 = \frac{x}{t} \Rightarrow x = t$

T-rex $x = \pi$

Octopus $v = \frac{x}{t} = \frac{1}{2} \Rightarrow t = 2x$

Drake $a = \frac{v}{t} = \text{constant}$

$a = \frac{x}{t^2} \Rightarrow at^2 = x$

$\Rightarrow t(x) = \sqrt{\frac{x}{a}}$

IN GENERAL

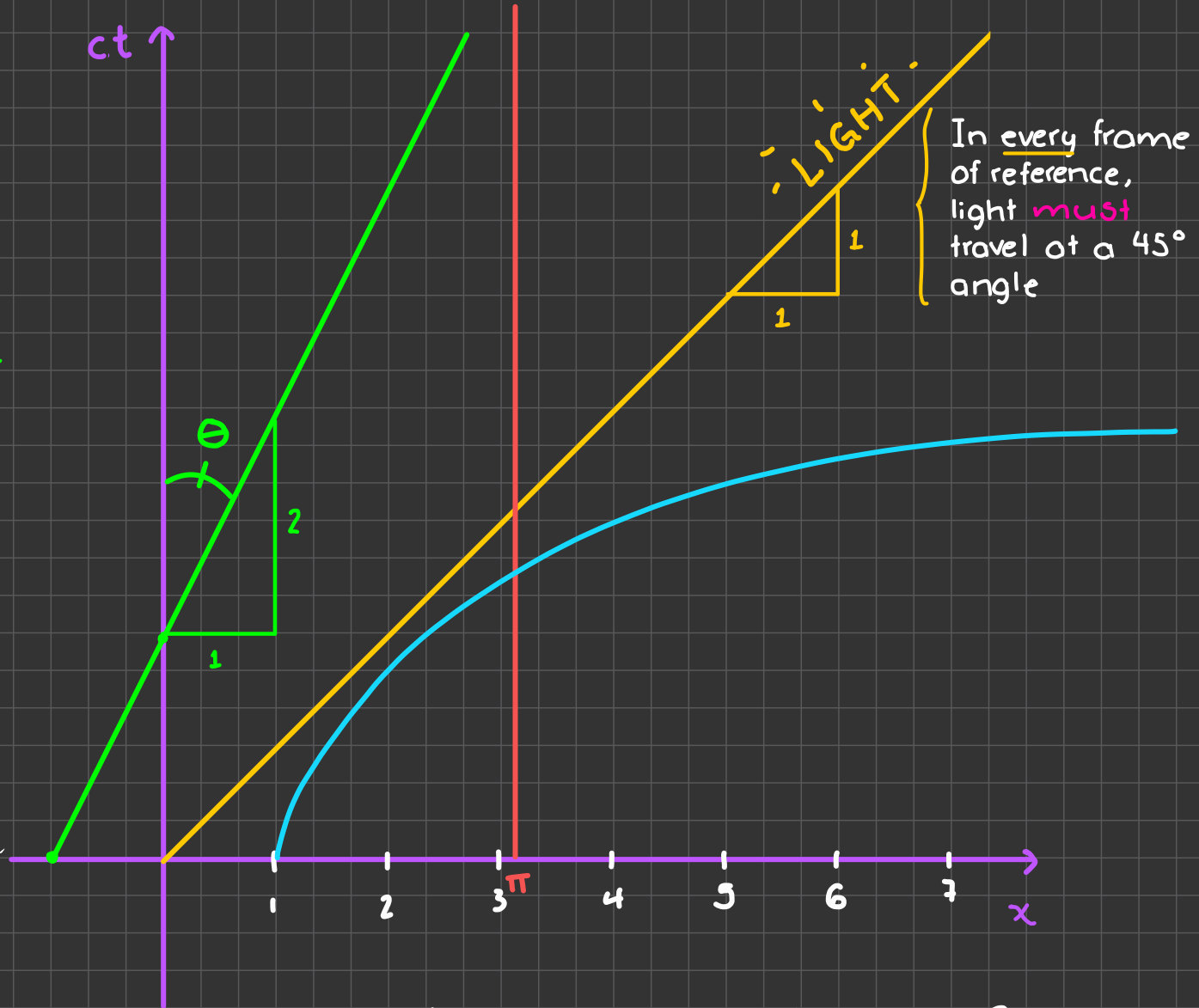
STRAIGHT line

constant speed

- Show that $\tan(\theta) = v$

CURVED line

there was a change of velocity



- What would an horizontal line mean?

