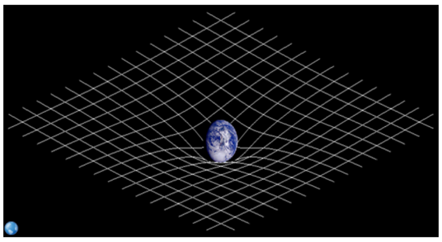
AP Phys 2 Unit 6.8 Notes - Classical Relativity

6.8 - Relativity

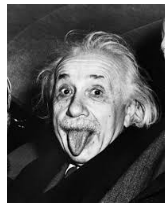


Classical Relativity

Until Einstein, it was held that physical laws apply to all frames of reference.

For example, measurements (such as mass, length, time) conducted by scientists moving at different velocities would be the same.

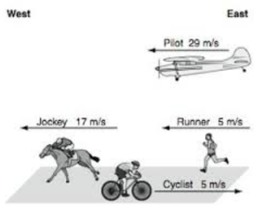
Imagine a train, for example, with a scientist measuring things, and a stationary scientist conducting the same measurements.



Classical Relativity

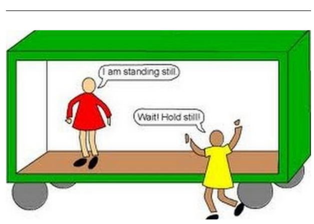
One thing of note is the concept of relative velocity (this will factor in later).

Each of the two scientists mentioned previously can consider themselves stationary with respect to the other (in other words, the perception is that the other person is moving).



Reference Frames

Inertial Reference Frame – A frame in which an object experiences no net force.
Non-Inertial Frame – A frame in which the observer is accelerated. A stationary (in an inertial frame) object viewed from this non-inertial frame would appear to move.



Inertia Example

A cup on the frictionless dashboard of an accelerating car will appear to move backwards without a force acting on it.

The driver, being in the non-inertial frame of the accelerating car, would have to invoke a fictitious force to explain the cup's movement.

From the perspective of someone outside the car (inertial frame), the cup would appear stationary.

Absolute Reference Frame

The need for an absolute reference frame arose with the calculation of the speed of light (c).

Would light travel faster if the source of light were moving, like a ball thrown forward from a moving truck?

According to Newtonian relativity: yes.

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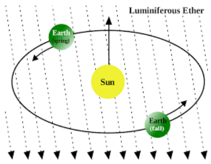
The Ether

It was widely thought that the light that reached Earth traveled through an undetected medium called the Luminiferous Ether.

This Ether was believed to be at rest, with the planets and rest of the universe moving WRT it.

The Michelson-Morley experiment was designed to measure the speeds of light at different times in the Earth's orbit.



The Michelson-Morley Experiment

This set out to measure the speeds of light at different times in the Earth's orbit from a variety of sources. The Earth's orbital velocity differs at different times of the year.

By comparing measurements of the speed of light, they were attempting to determine the relative "speed" of the Earth through the Ether.

Their equipment was crude by today's standard, but capable of measuring the speed of light.

The Michelson-Morley Experiment

Results: no difference of light speed at any time, measuring any light source.

The Ether idea was ultimately abandoned, although it took a better theory to supplant it.

Einstein

Einstein had a feeling that there was no fundamental reference frame.

He postulated that *all* the laws of physics are the same in all inertial reference frames.

He concluded that the speed of light in a vacuum is constant, regardless of the frame from which it is observed, and from which it originated.

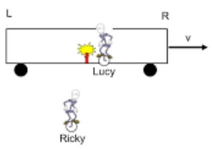
Simultaneity

This is the concept that simultaneous events occur at the same time for all inertial reference frames.

Einstein thought about it and argued that this was not necessarily true.

Two simultaneous light-producing events might be seen differently by different observers, depending on how they are moving.

Ex: firecrackers on a train.

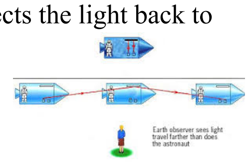


Time Dilation

Another of Einstein's thought experiments had to do with the passage of time in different inertial reference frames.

He concluded that moving clocks are observed to run more slowly than clocks that are at rest in the observer's own frame of reference.

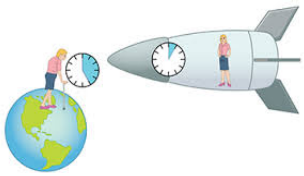
This argument had to do with a light pulse clock, which is nothing more than a light source that sends a beam up to a mirror which reflects the light back to the source. Drawing.



Time Dilation Calculation

The observed difference between time passage can be calculated!

$\Delta t = \gamma \Delta t_0$	Δt = time observed in non-moving frame γ = gamma Δt_O = time observed in moving reference frame (from non-moving frame)



Time Dilation Example

How much time has elapsed from the viewpoint of a stationary observer if a clock moving at 0.6c shows the passage of 20 minutes?

Find γ: $\gamma = \dfrac{1}{\sqrt{1-(0.6)^2}} = 1.25$

Find Δt: $\Delta t = 1.25 \bullet 20\, minutes = 25\, minutes$

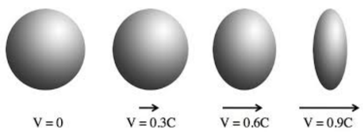
Length Contraction

Length also changes with changes in speed.

An object's length is largest when measured by an observer in that reference frame (a 'proper' observer).

If the object is moving, it will have a shorter measurement WRT the non-moving observer.

$L = \dfrac{L_o}{\gamma}$	L = Contracted length L_O = Length measured from observer in object's frame. γ = gamma



Twin Paradox

I read this and my head exploded.
Let's read it together – Page 888.