



# Special Relativity

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*How amazing, fantastic, strange, and wonderful nature  
is... and the more you look the more there is to see.*

# Special Relativity

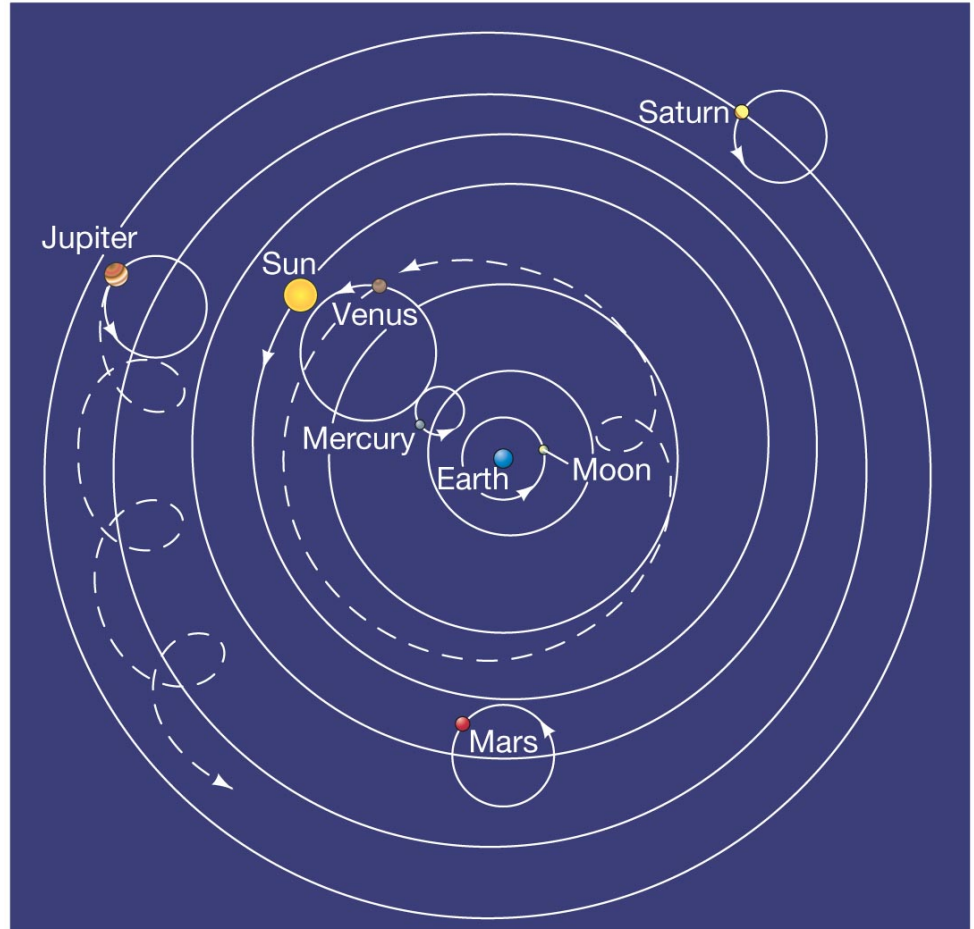
*How amazing, fantastic, strange, and wonderful nature  
is... and the more you look the more there is to see.*

*Seeing what is by letting go  
of what is "known".*

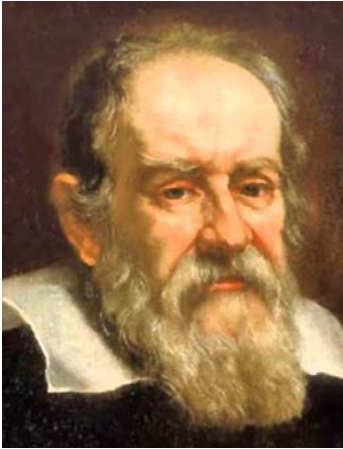


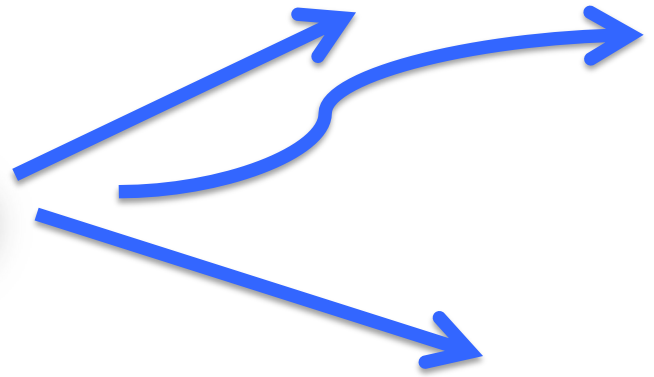
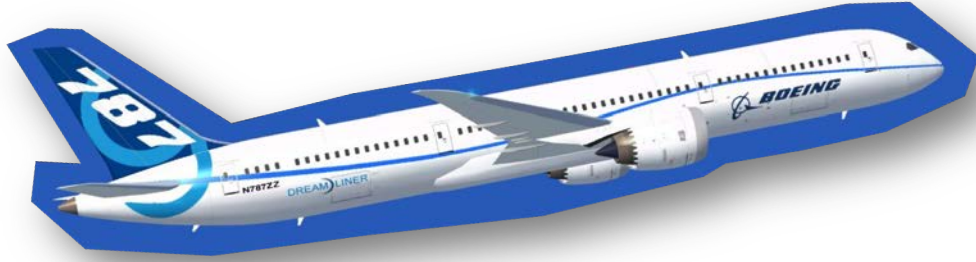


Claudius Ptolemy  
est. 85 - 165



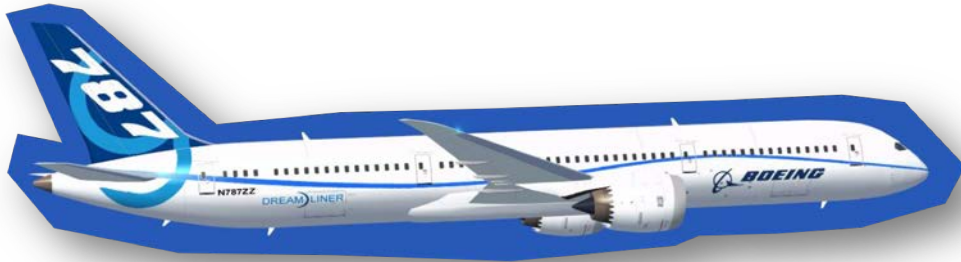






**Uniform Motion** (opposed to non-uniform, or accelerated motion) is special.

We don't sense uniform motion. Gravity influences non-uniform motion.







Special  
Relativity

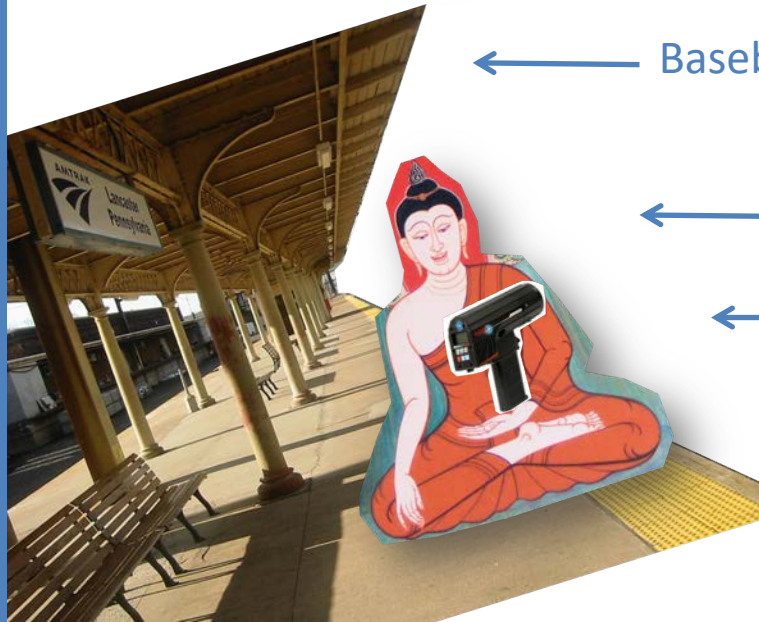
Motion

Space

Waves

SWTBD

Conclusions



← Baseball moving 10 mph

← Train moving 20 mph

← Ball is moving 30 mph

How fast is the ball *really* moving?



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Relativity

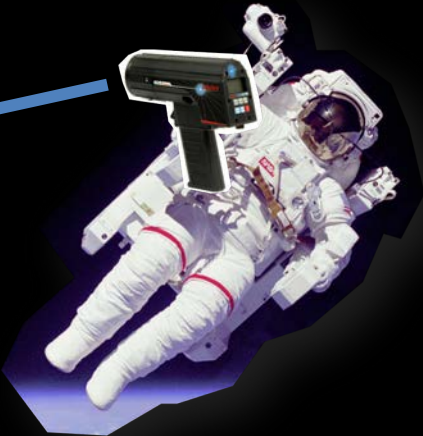
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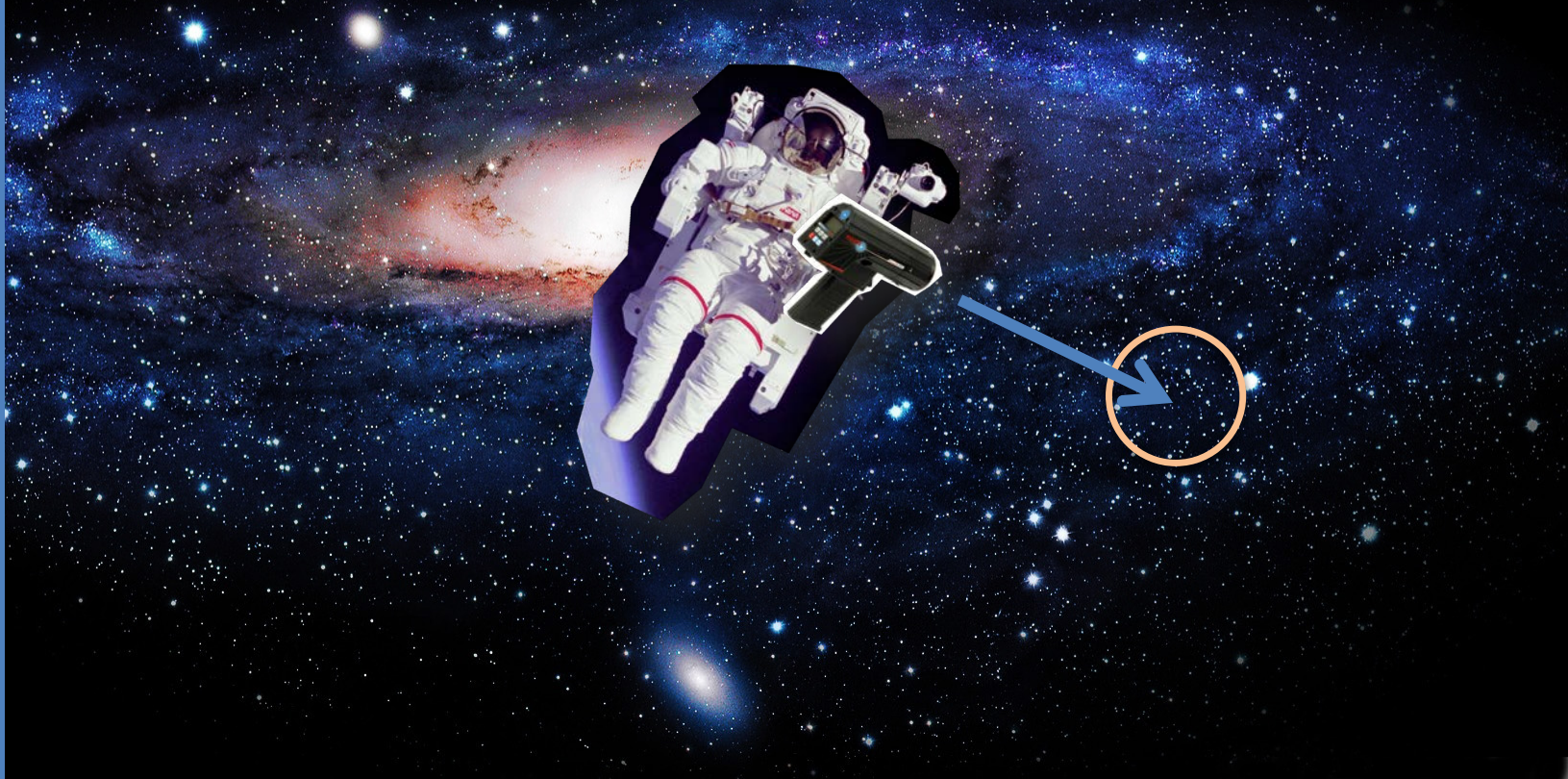
Conclusions



← Earth rotating on its axis 1,000 mph  
Train moving 20 mph  
Ball moving 10 mph  
  
Ball is moving 1,030 mph

Galaxy is rotating 483,000 mph  
Earth rotating on its axis 1,000 mph  
Train moving 20 mph  
Ball moving 10 mph

Ball is moving 484,030 mph



What is the right frame of reference?  
*How fast is the ball really moving?*

They are all right.



Special  
Relativity

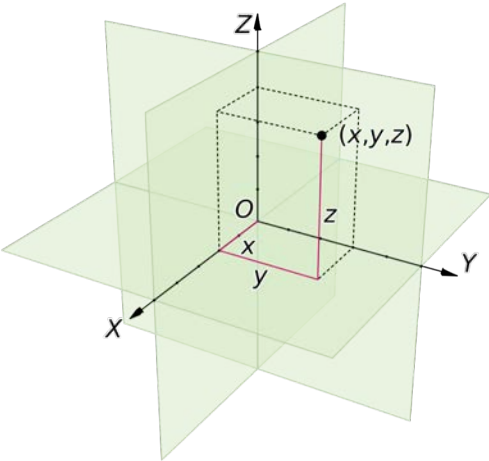
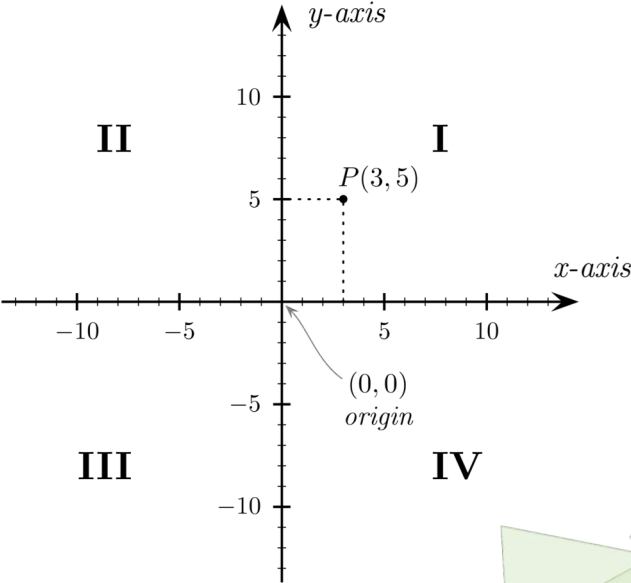
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Special  
Relativity

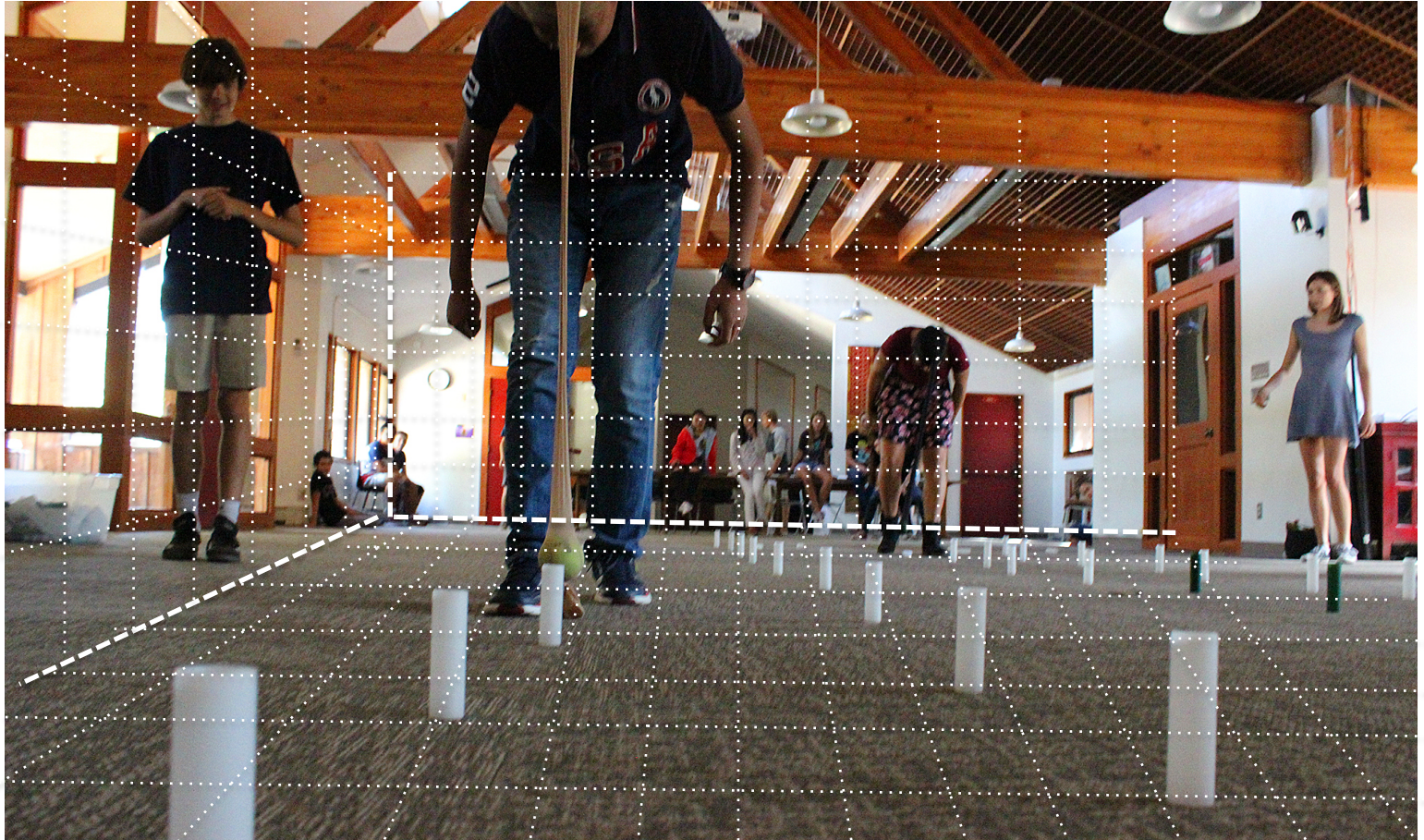
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Waves

SWTBD

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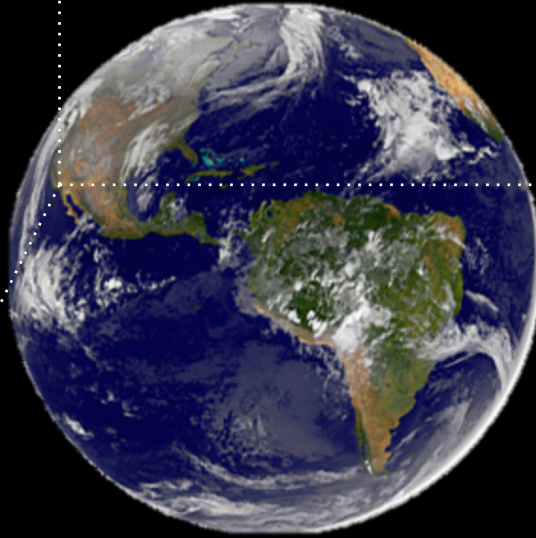
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Space

Waves

SWTBD

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# Special Relativity

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Space

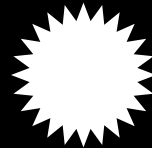
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**Inertia** – The tendency of an object to stay at rest or in uniform motion until acted upon by a force.



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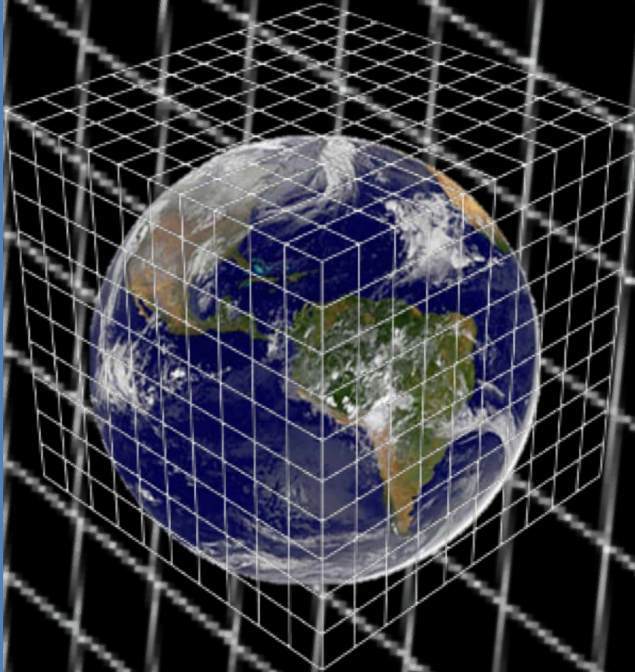
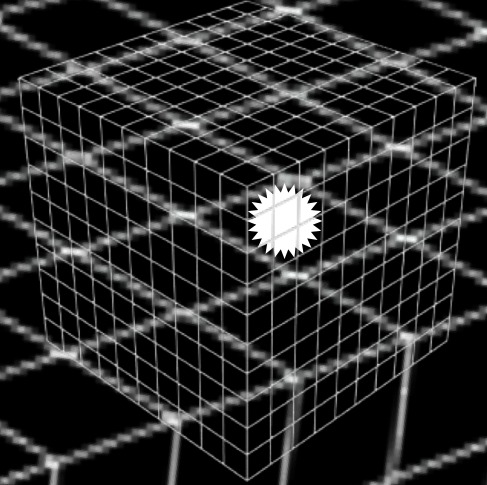
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What is the right frame of reference for measuring space  
and objects in space?

*How big is it really? How far away is it really?*

They are all right.

Speed will effect time and space, as we will see.



Special  
Relativity

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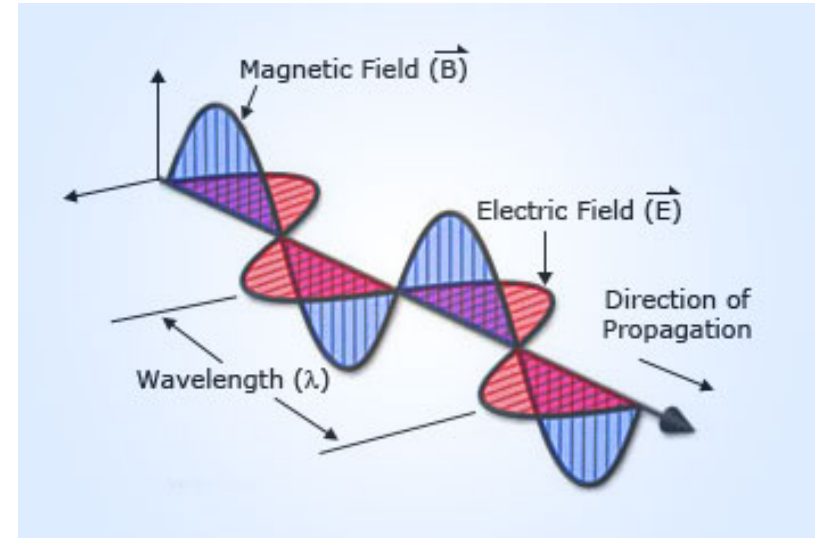
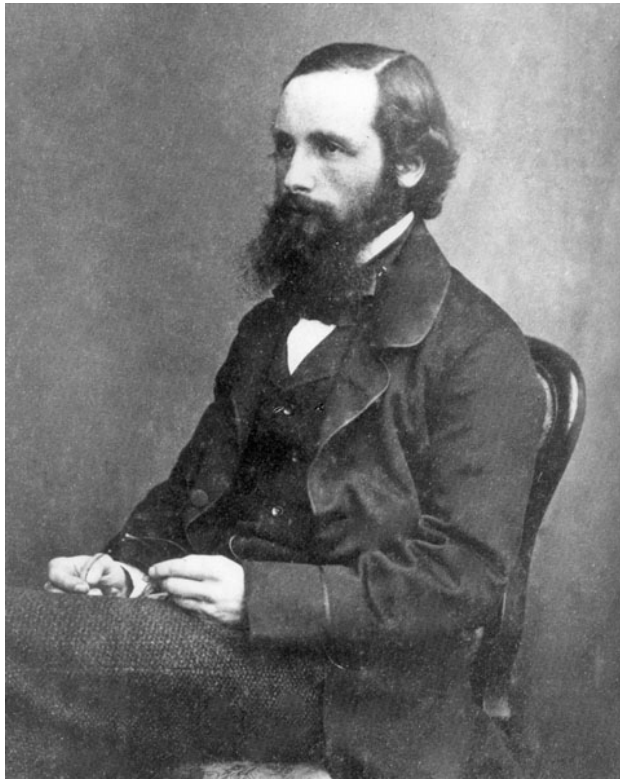
SWTBD

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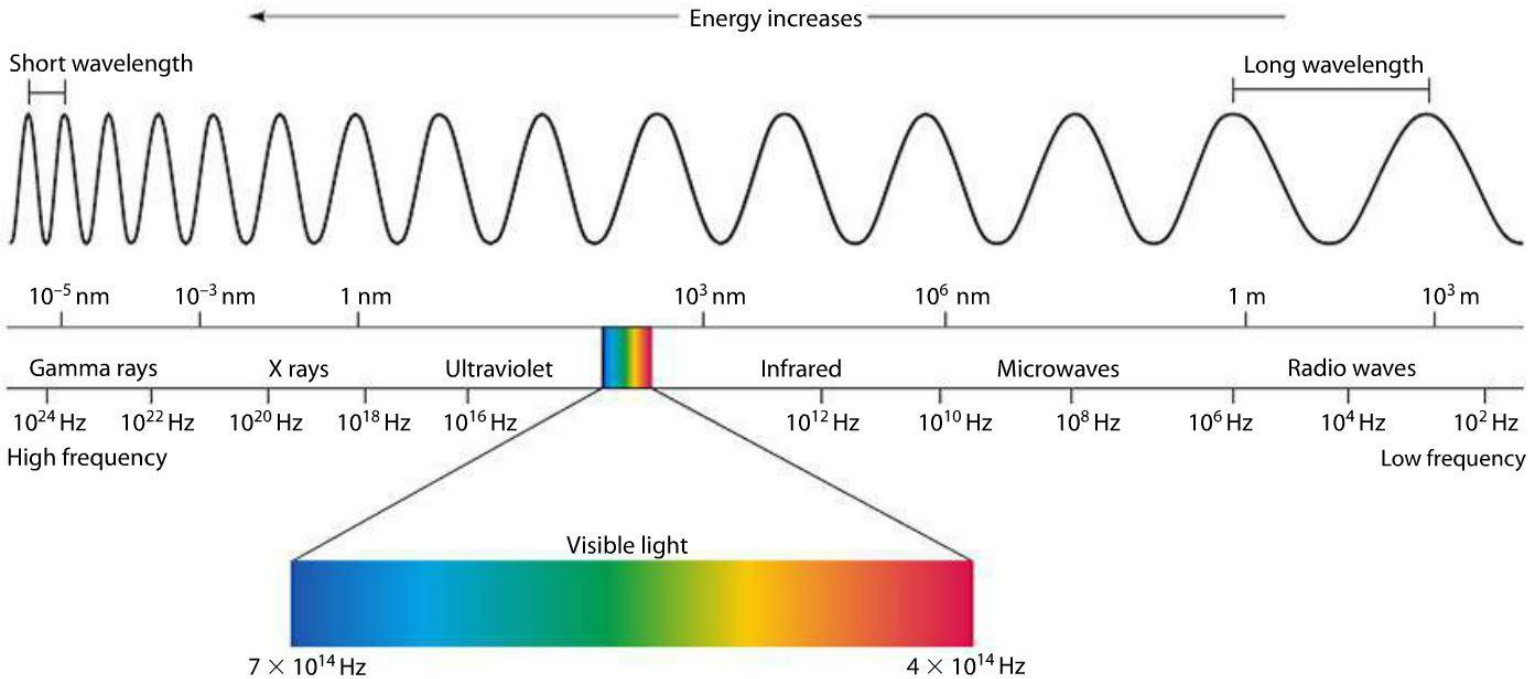
Energy and medium.





All electromagnetic waves move  
at a constant speed –  $C$  – in a vacuum.

# The Electromagnetic Spectrum



How fast is speed **C**?

300,000,000 meters per second, or 186,000 miles per second.

Sunlight takes 8 minutes to travel to Earth.

Our fastest aircraft travels .000405% **C** (New York to LA in 20 minutes).

Speed of sound is 761 mph at sea level.

**Is C a limit, and what is the medium?**

Wind west - 5 mph



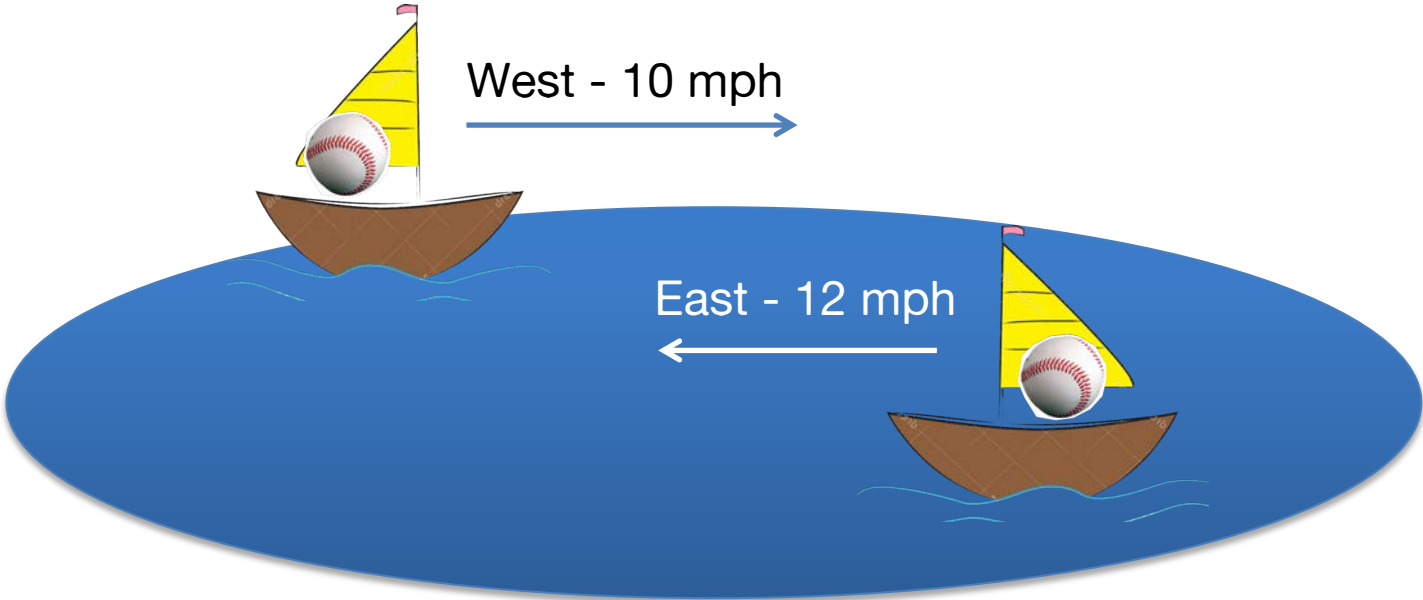
West - 10 mph



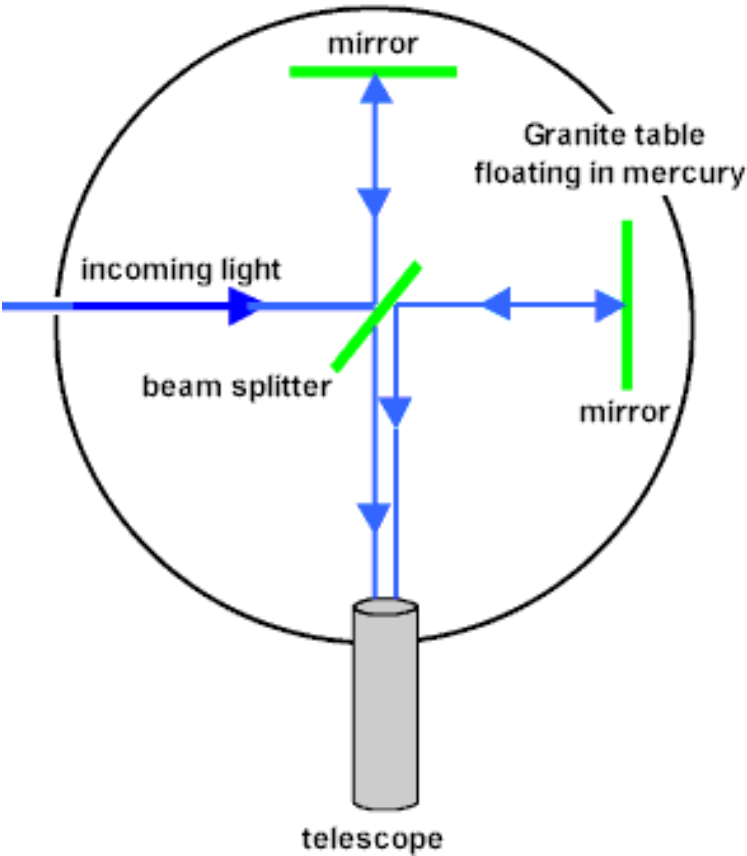
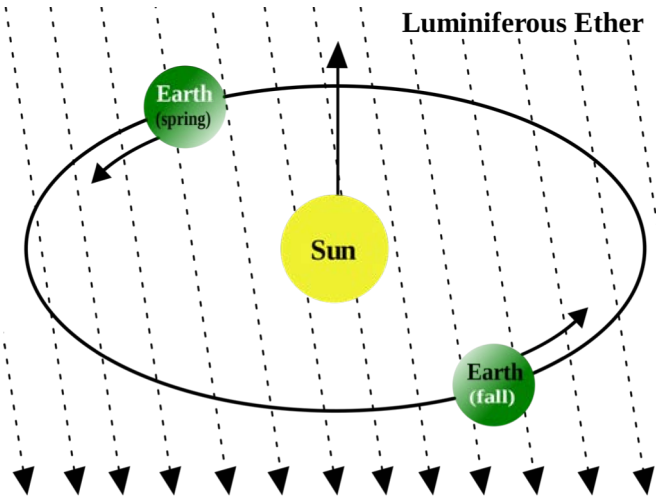
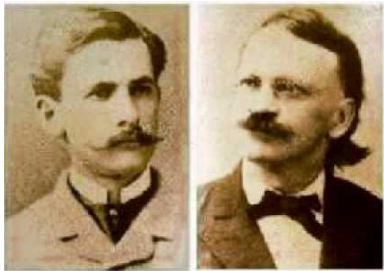
East - 12 mph



Current moving east 2 mph



Limit and Medium – Ether.





What did Michelson and Morely expect to find:



- 1) When the light was measured in opposite directions, 6<sup>th</sup> months apart, there would be a slight difference in speed.
- 2) The perpendicular differences would create a slight difference in speed.
- 3) From there they might conclude how ether affects light (such as wind affecting the speed of sound waves) and in what direction the ether might be moving.

What did they find:

**The speed of light NEVER changed.**

It was constant in all directions, moving toward you, away from you, with the direction of the Earth's motion, and against the direction of the Earth's motion. Other scientists confirmed their findings.

This created a huge crisis. Something about what we thought we knew must not be right.



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1905 - Einstein to the rescue. Speed  $C$  is a constant and a limit, and applies to all frames of reference. SWTBD?

Special  
Relativity

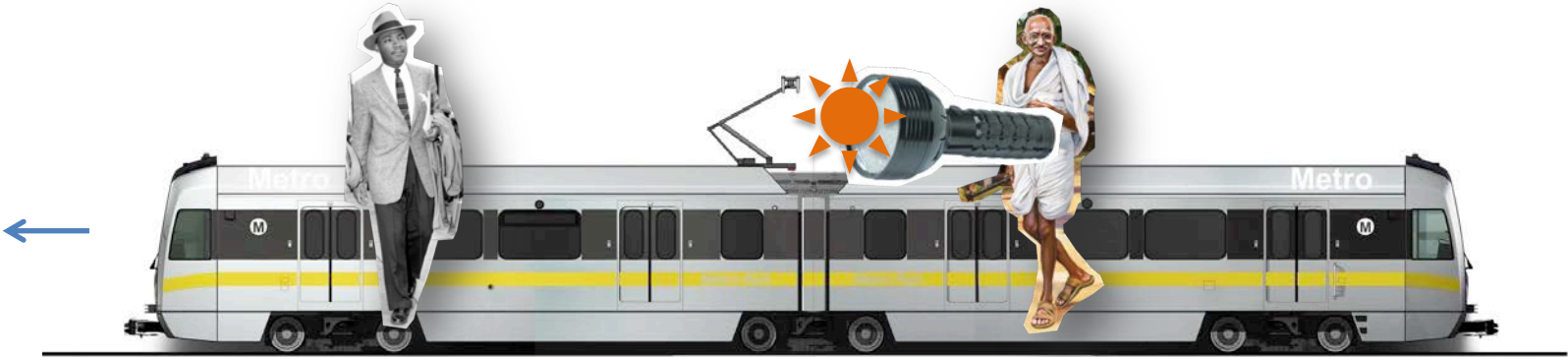
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← Train is moving  $.5 C$

← Light particle is moving  $C$

**What does speed does Malala measure for the moving light?**



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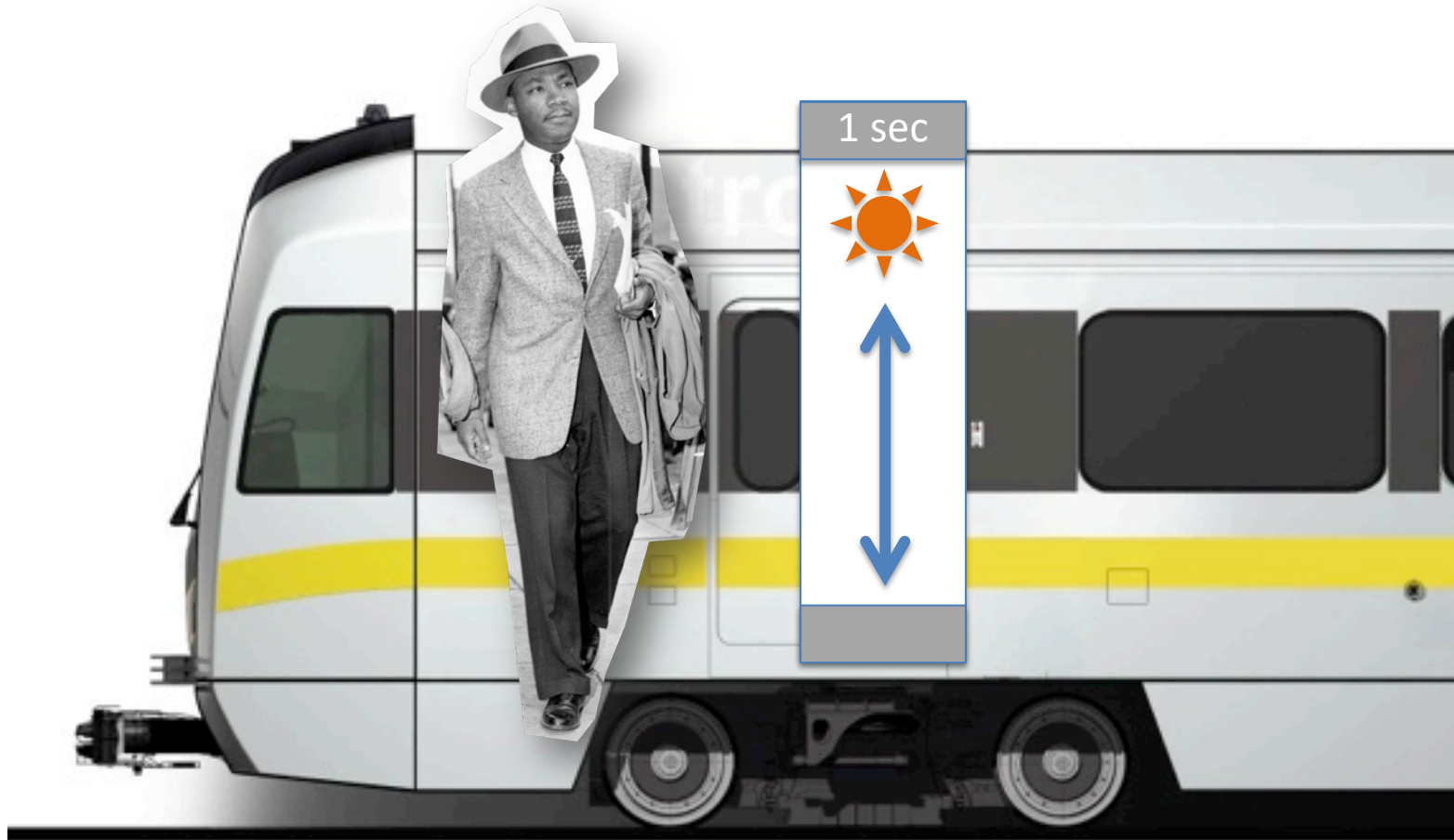
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SWTBD

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Special  
Relativity

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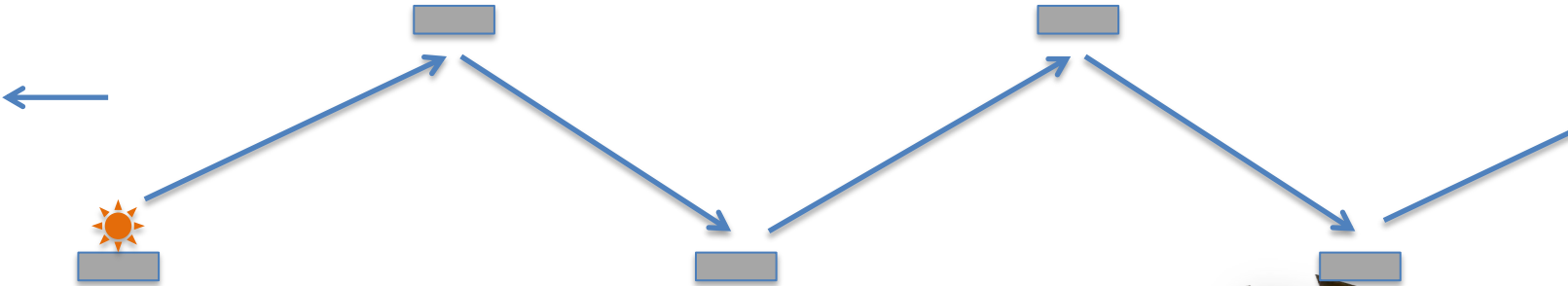
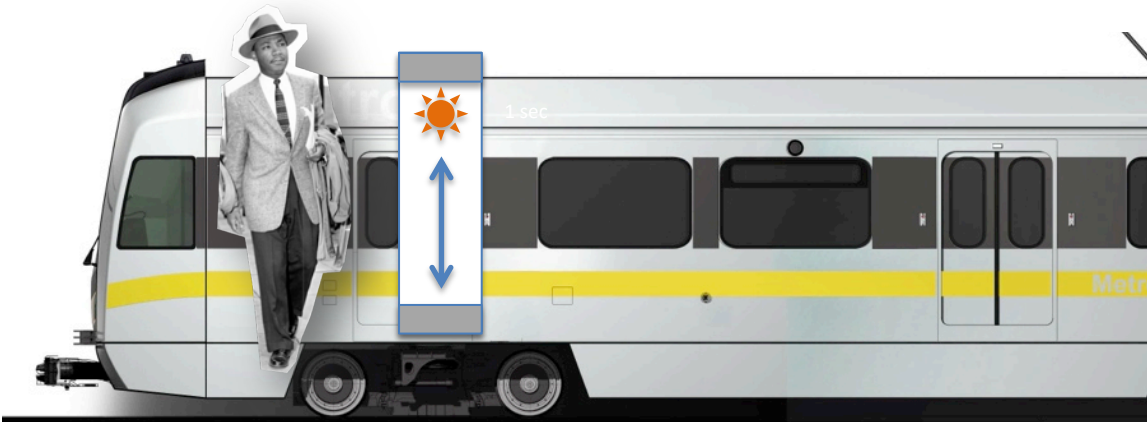
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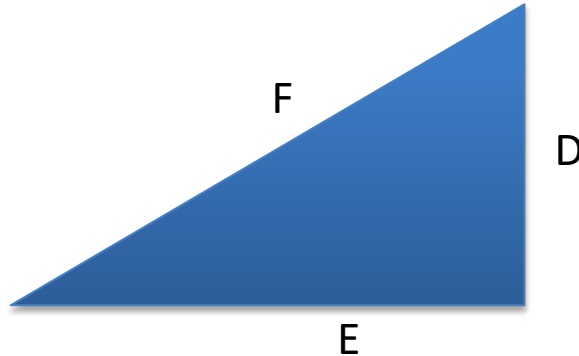
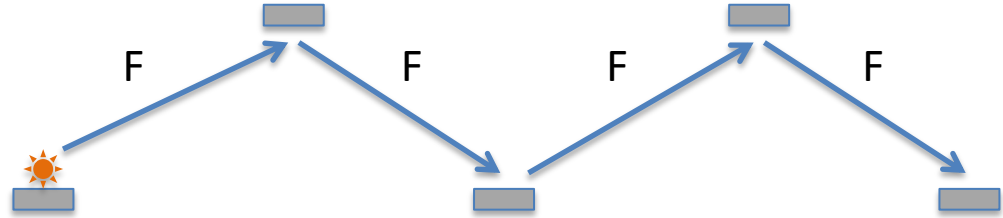
Conclusions

Train is moving .5 C



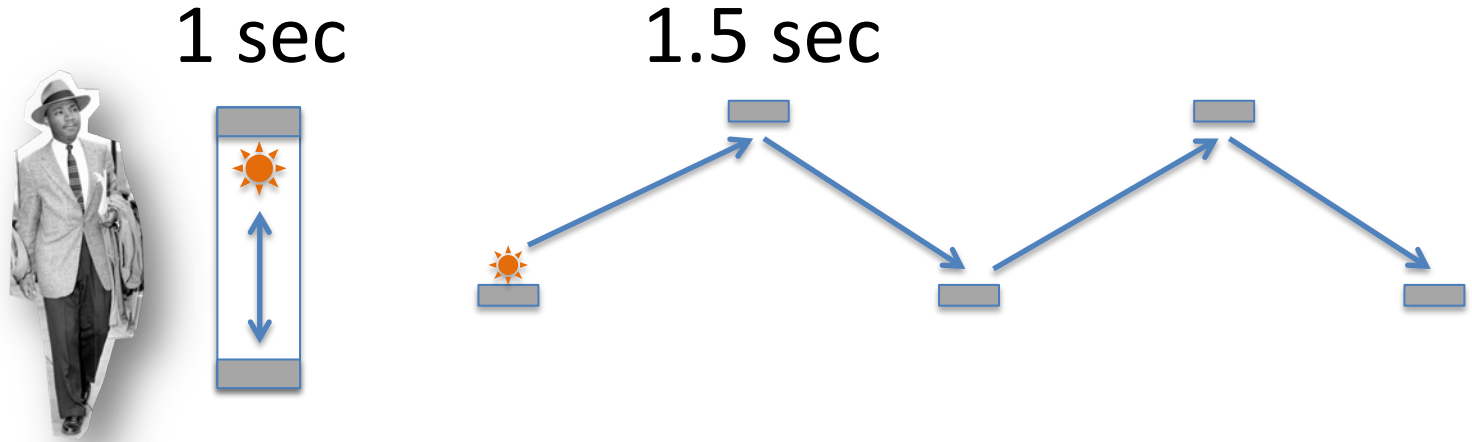


D



For MLK in the train, light is moving C.  
For Malala on the platform, light is  
moving C.

**Malala is seeing MLK  
experience time more  
slowly than she is.**



For every 2 seconds that pass for MLK, 3 seconds pass for us.

The only way time can flow the same for MLK and Malala is for the light to move  $1.5C$  from the platform.

When MLK finally stops, his watch and Malala's WILL NOT MATCH.

**We have never noticed this because we don't move very quickly.**



Special  
Relativity

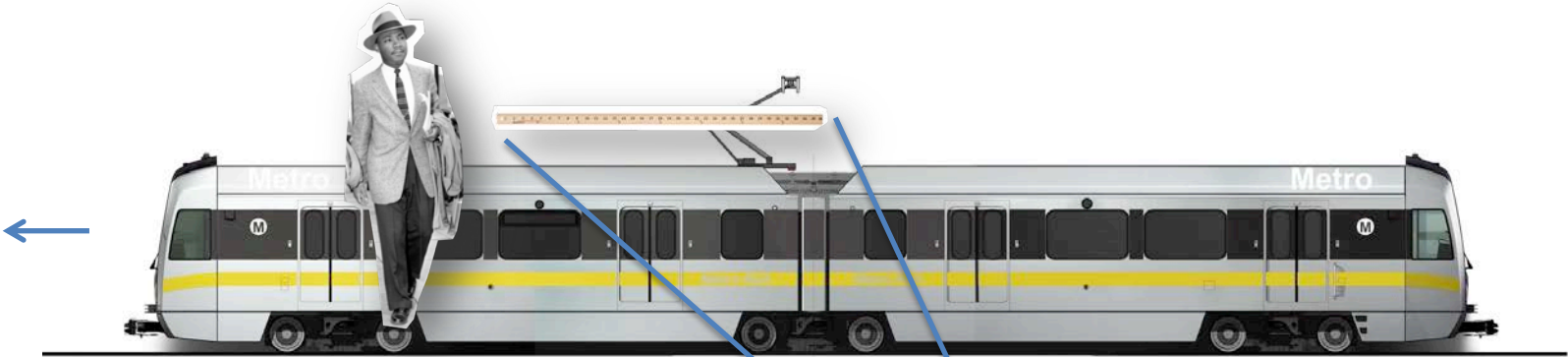
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Space

Waves

SWTBD

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← Train is moving .5 C



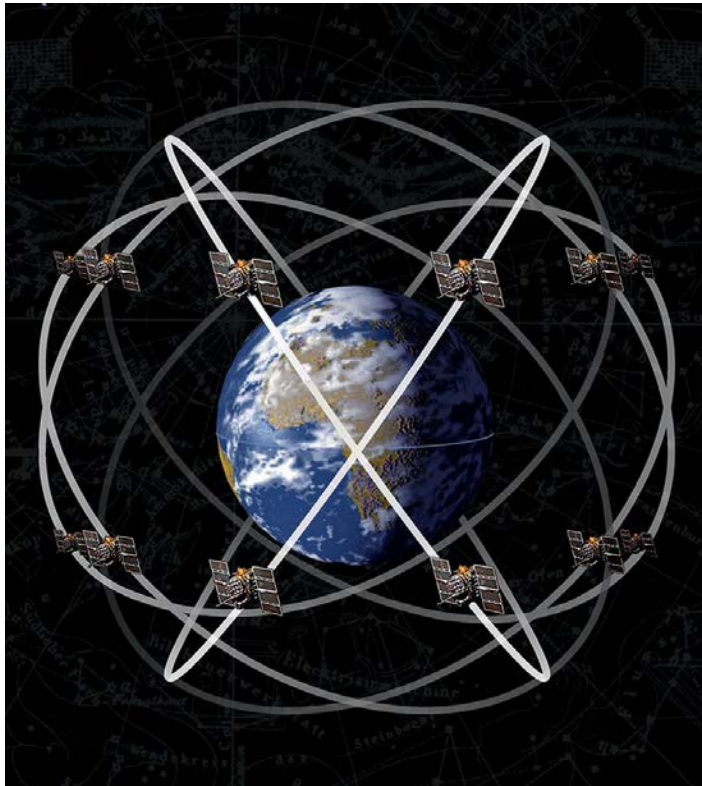
Everything on the train will shorten  
for Malala. Everything on the  
platform will shorten for MLK.



If  $c$  is constant there ***is no*** absolute time and space.  
If there ***is*** absolute space and time,  $c$  can not be a constant.

**Questions of time and space are answered within a frame of reference.  
Equations can help us address differences in frames of reference.**





**Global Positioning System.** 24 satellites in orbit 20,000km from the ground, moving 14,000km/hour. If speed and gravity near the surface were not taken into account (clocks are not in synch), then each satellite would be off by 45 microseconds per day, resulting in an offsetting of 10 KM by the end of each day, which would make GPS useless.

And there are many more examples.

*Why is this surprising? Because we are moving relatively slowly, and we are neither too big nor too small.*

*How amazing, fantastic, strange, and wonderful nature is... and the more you look the more there is to see.*

*Sometimes we come to the truth of what is by letting go of what we think we certainly know.*

*The practice of imagination and wondering.*

