RELATIVITY CHALLENGE

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Episode 19
The Real Meaning Behind Newton's, Lorentz's and Einstein's Equations

Presented by Steven Bryant

Background

We have avoided discussing the "meaning" behind the transformation equations,… Until Now!

- Why Not?
  - Needed to show math problems without "interpretation" confusion
  - Needed to show better math results without relying on "interpretation"
- Why Now?
  - Shown better accuracy for certain experiments
  - Shown the mathematical problems with Einstein's derivations
  - Need to discuss what "it" means

Agenda

The goal is to explain the foundational elements and assumptions that make up SRT, other moving system models, and the CICS model.

- Explain the “meaning” of the Moving System Models
  - Explain Transformations in Moving Systems
  - Explain Wavelength in Moving Systems
- Explain “what” problem is solved by Newton’s, Lorentz’s and Einstein’s equations
- Explain the key misunderstanding that leads to the false conclusions of *Time Dilation* and *Length Contraction*

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Part 1 - Transformations

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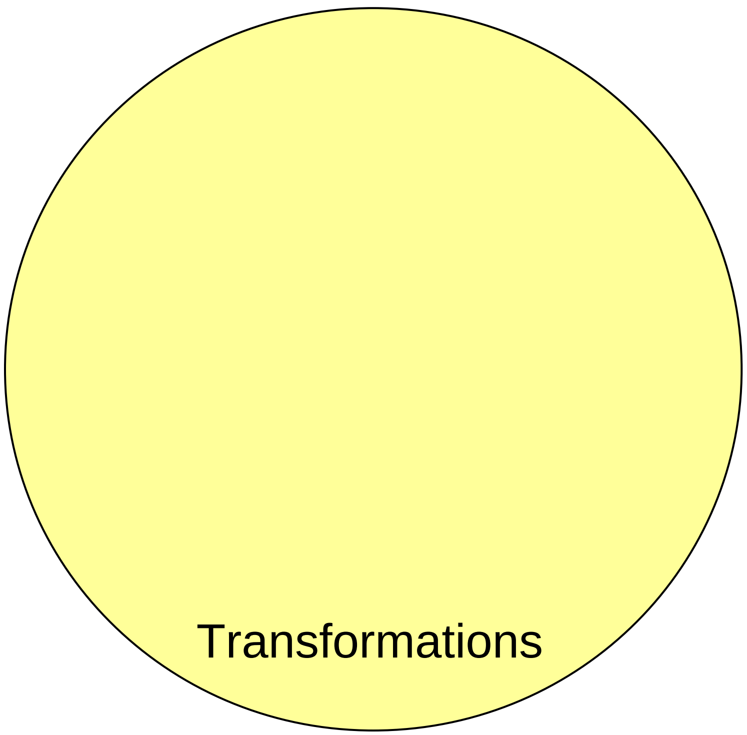
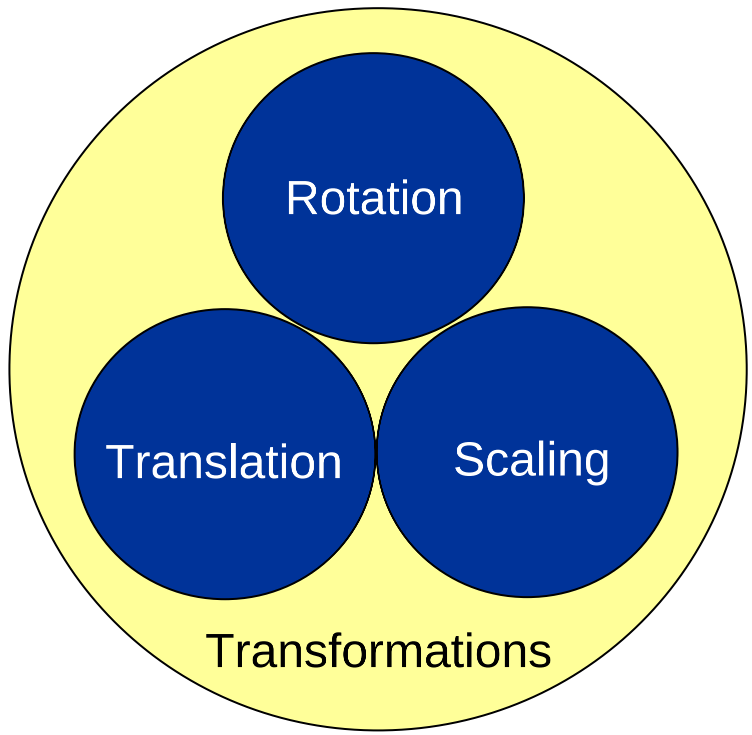
Part 1: Transformations

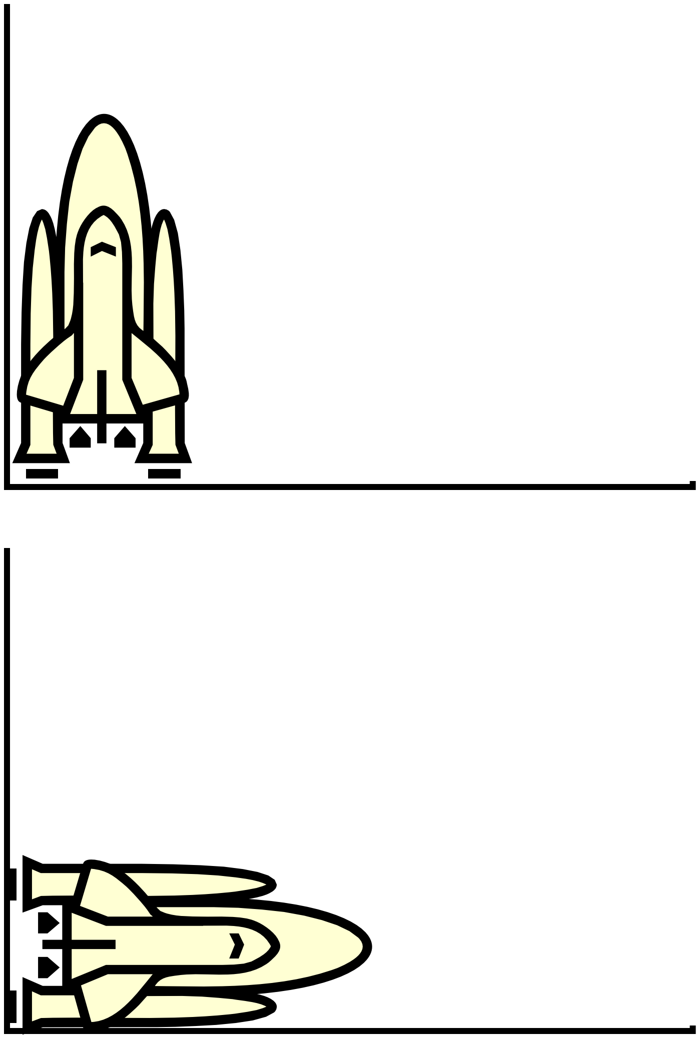
Current Definition
for
Moving Systems



Geometric Transformations
for
Moving Systems



Part 1: Rotation

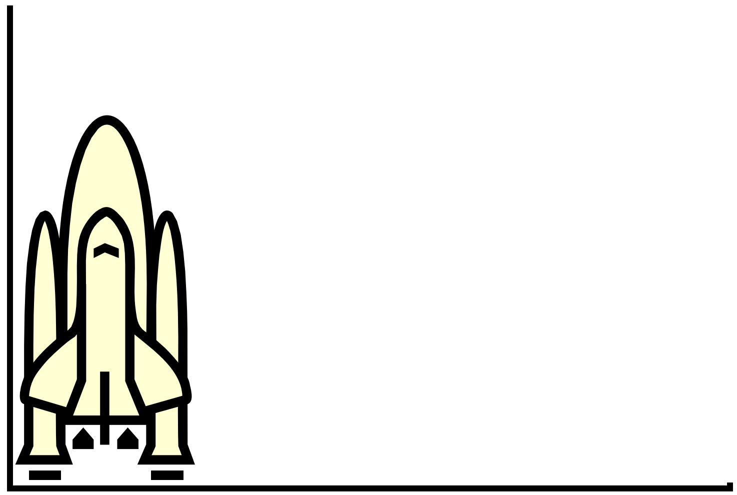


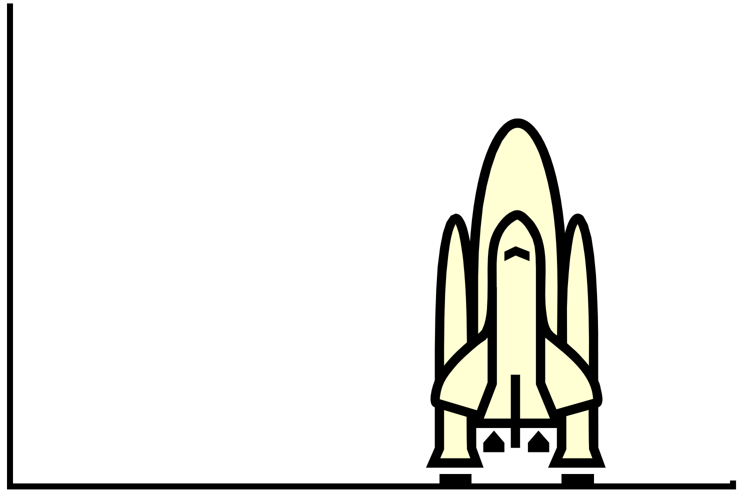
Rotation is the operation that ***changes the <u>orientation</u>*** of an object in a coordinate system.

Key Points

- Mathematically performed using *sin* and *cos*
- Changes the orientation and *may* change position
- Maintains the size, shape, and distance from the Origin
- Rotation can be based on the passage of time
- An example of rotation is the movement of the end of a second hand on a wristwatch

Part 1: Translation



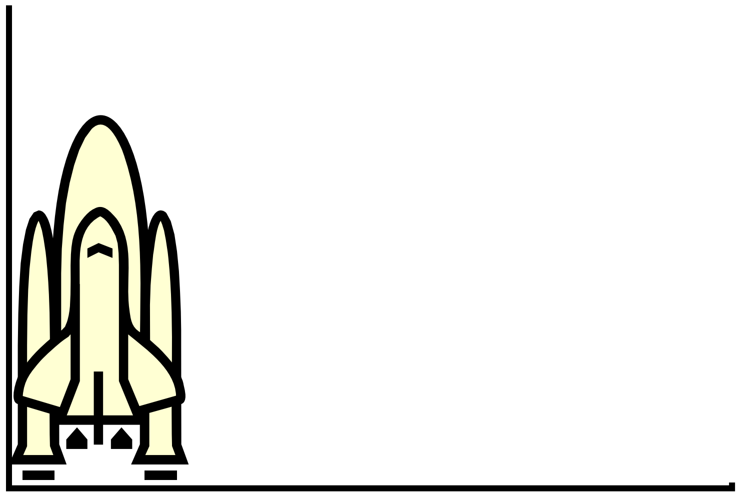


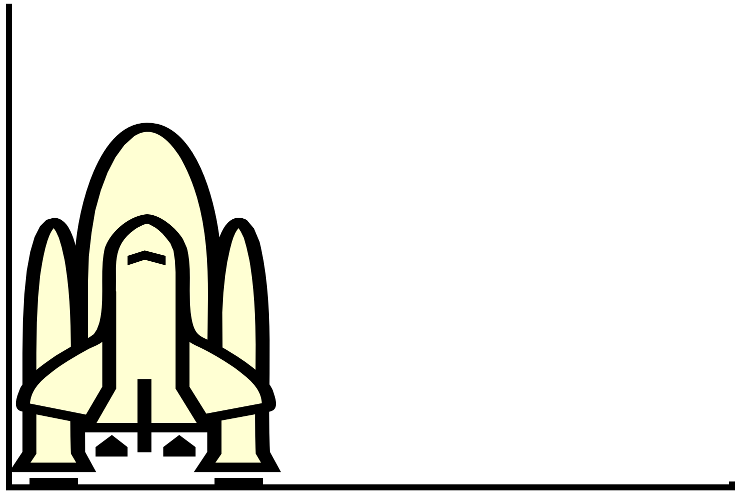
Translation is the operation that ***changes the <u>position</u>*** of an object in a coordinate system.

Key Points

- Mathematically performed using *addition* or *subtraction*
- Maintains the orientation, size, and shape
- Changes to position and *may* change the distance from the Origin
- Translation can be based on the passage of time
- An example of translation is the movement (change in position) of your car while driving at 60 miles per hour

Part 1: Scaling



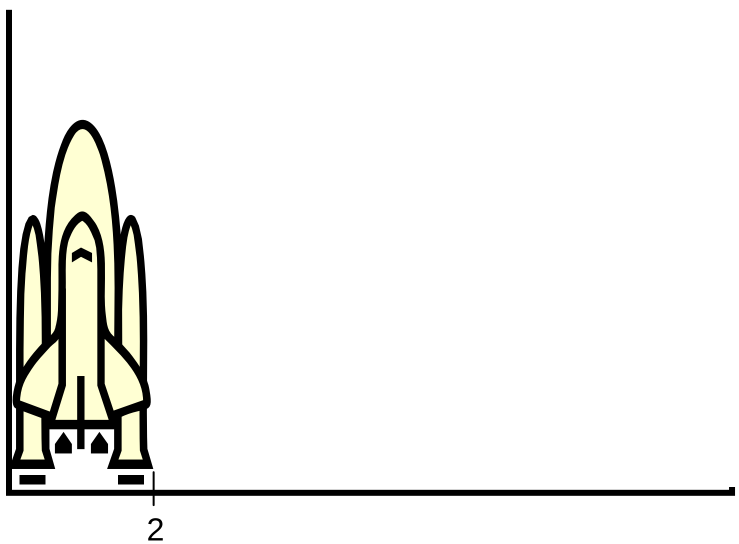


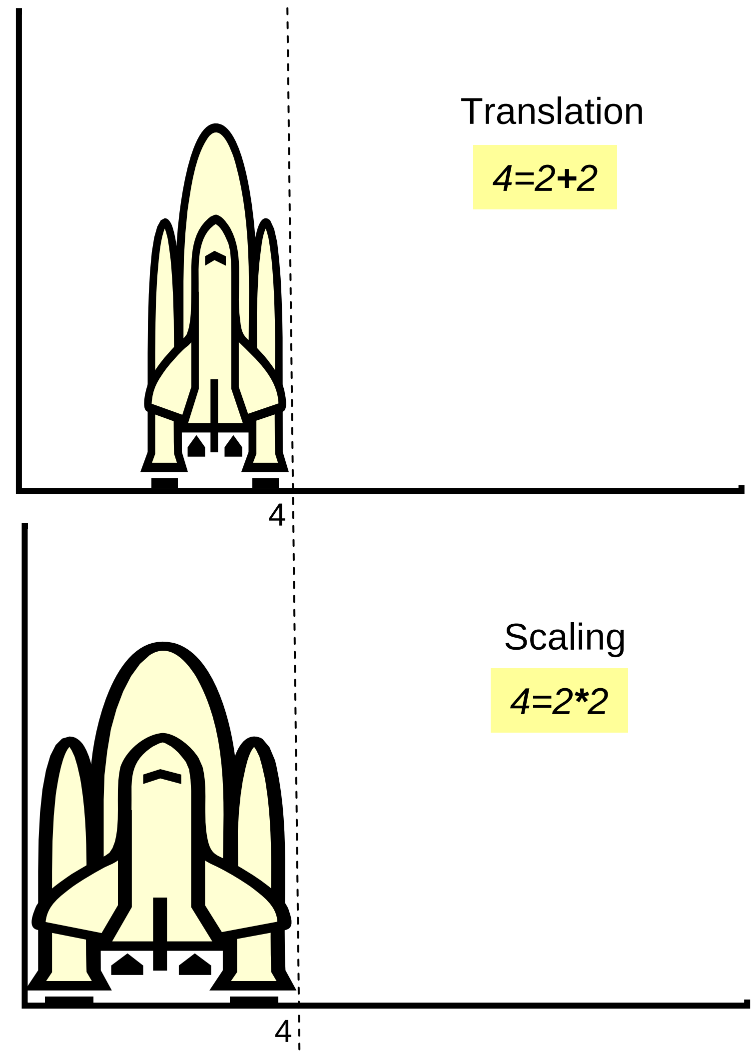
Scaling is the operation that ***changes the <u>size</u>*** of an object in a coordinate system.

Key Points

- Mathematically performed using *multiplication* or *division*
- Maintains the orientation, position, and distance from the Origin
- Changes the size and shape
- Used to change Rates
- Scaling can be based on the passage of time
- An example of scaling is pulling the ends of a rubber-band away from each other

Part 1: Watch Out!





Do not confuse the types of ***Transformations*** just because they produce the same or similar mathematical results!

Part 1: Summary

The specific types of *Transformations must not be mistaken for one another*.

Transformation Type	Mathematical Operation	Characteristics
Translation	Addition or Subtraction	Same Size and Shape * Different Position * Different Distance from Origin Same Orientation
Scaling	Multiplication or Division	* Different Size and/or Shape Same Position Same Distance from Origin Same Orientation
Rotation	Trigonometric Operations	Same Size and Shape * Different Orientation * Possible Different Position Same Distance from Origin

Key Points

- There are more than one type of transformation
- Translations and Scaling are not the same thing
- Translation uses addition and subtraction
- Scaling uses multiplication and division
- Each type of transformation answers a different type of question
- Drawing the picture can aid in determining the type of transformation

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Part 2 – Wavelength & Frequency

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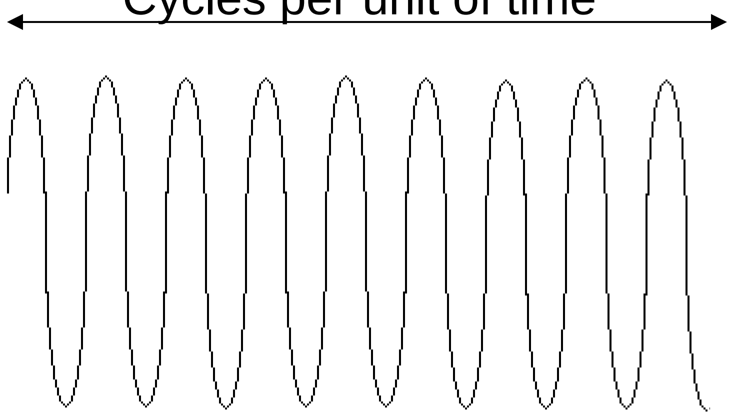
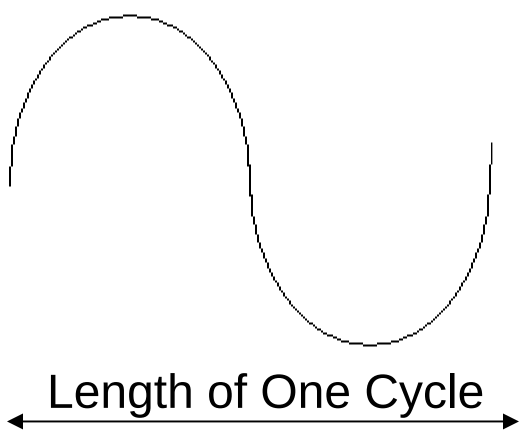
Part 2: Frequency and Wavelength

Cycles per unit of time

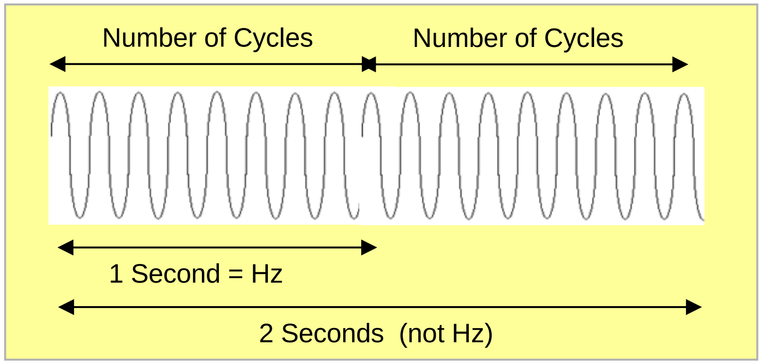


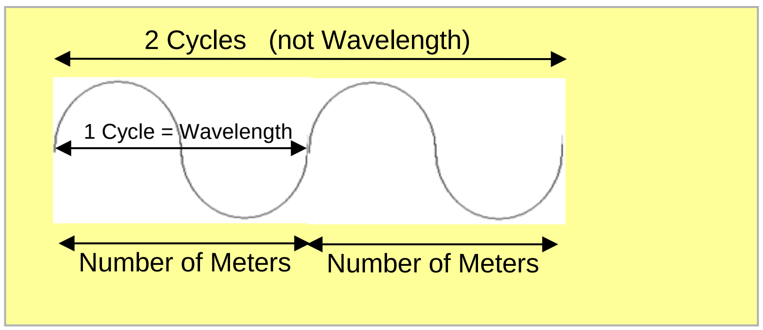


Length of One Cycle

- **Frequency**
  - Is the *Number of Cycles* that occurs in *some amount of **time***
  - The *Number of Cycles* that occur in *1 Second* is defined as *Hertz*
- **Wavelength**
  - Is the Length of One Cycle of a given Frequency
  - Wavelength is found by dividing the Frequency by the distance covered by those cycles in one second

Part 2: Watch Out! Distinguishing Wavelength from Length





- Imagine a mirror is held 300,000,000 meters from a light source. A light is directed at the mirror at frequency f Hz.
  - How many cycles are between the light source and the mirror?
- Now the mirror reflects the light back to the light source.
  - How many cycles are between the light source and the mirror?
  - How many cycles are there in this round trip journey light source to mirror to light source?
  - What is the frequency?
  - What changes if we use Wavelength instead of cycles in each of the questions above?

Key Points

- Frequency and Wavelength can be thought of as types of Rates
- Cycles are not the same thing as Frequency -> How many cycles **per 1 second**
- Length is not the same thing as Wavelength -> How many meters **per 1 cycle**
- Mathematically, Wavelength behaves mores like Frequency than Length.

Part 2: Frequency & Wavelength Scaling

The Moving System Models must explain what happens to frequency for each of the combinations of moving and stationary senders and receivers.

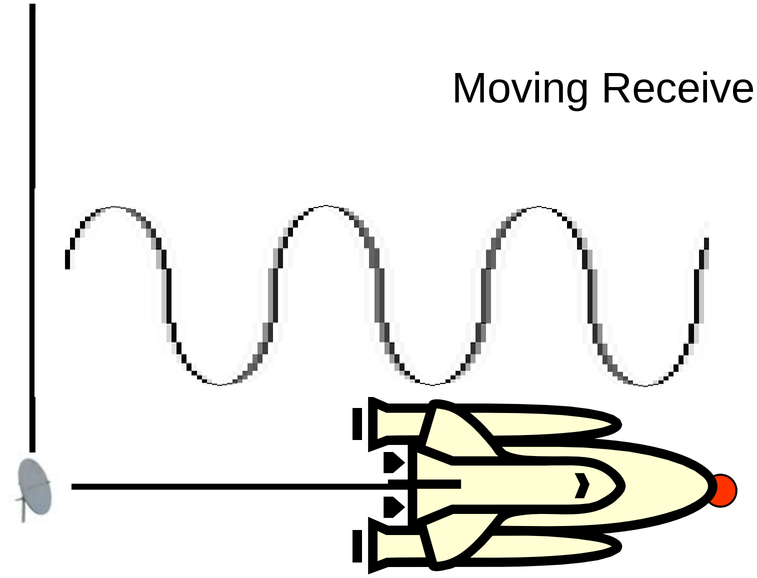
Frequency & Wavelength Scaling Behaviors		
Sender	**Receiver**	
	Stationary Receiver	**Moving Receiver**
Stationary Sender	Reference (No Scaling) & Complete Coordinate System I	Frequency or Wavelength Scaling (e.g., Doppler Shift) II
Moving Sender	Frequency or Wavelength Scaling (e.g., Doppler Shift*) III	**Explained Differently** By Each Moving System Model (e.g., Incomplete Coordinate System versus SRT) IV

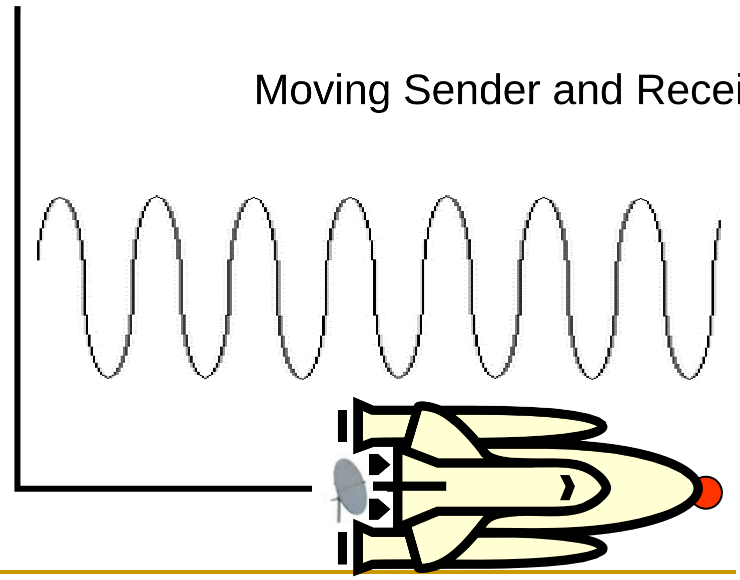
- Each Moving Systems Model must explain what happens to Frequency in response to a Moving Sender or Receiver
- The Moving Systems Models Treat the Moving Sender / Moving Receiver Case Differently
- In the CICS Model, a Complete Coordinate System behaves like the Reference case
- Quadrants 2 and 3 require the right use of Transformations
- The 4th Quadrant requires the right use of Transformations and the proper mathematical treatment of Wavelength and Frequency

Part 2: Scaling Frequency & Wavelength

- **Moving Receiver**
  - Wavelength "received" by the receiver is longer (or shorter) than original
  - Frequency Change is explained as "Doppler Shift" and does not result in conclusions of Time Dilation or Length Contraction
  - Symmetrical Waveform
  - Uses Doppler equations in one direction or the other

- **Moving Sender and Receiver**
  - Wavelength "received" by the receiver is slightly longer than original
  - The moving systems models handle this "Frequency Change" differently
  - Asymmetrical Waveform (e.g., "Long line" and "Short line")
  - Equations are based on combining Doppler equations in both directions





Part 2: Summary

- Getting the Units Right is Critical
  - Wavelength (Meters per cycle) is different than Length (Meters)
  - Frequency (Cycles per second) is different than number of Cycles
- Scaling of Rates
  - Used to change *Wavelength*
  - Used to change *Frequency*
- Received Frequency changes if the Receiver is in motion
  - One observer in motion: When the sender is not in motion (or visa versa), this is called Doppler Shift
  - Two observers in motion: The Moving System Models differ in how they treat the case where both the sender and the receiver are in motion.

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Part 3 - The Meaning Behind Each Model

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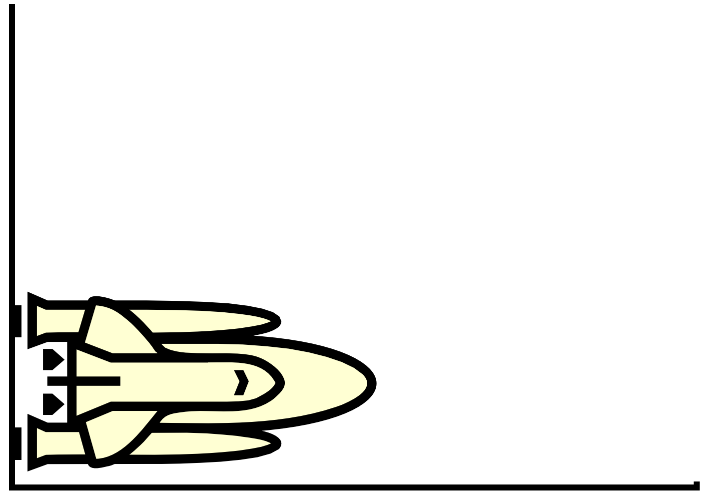
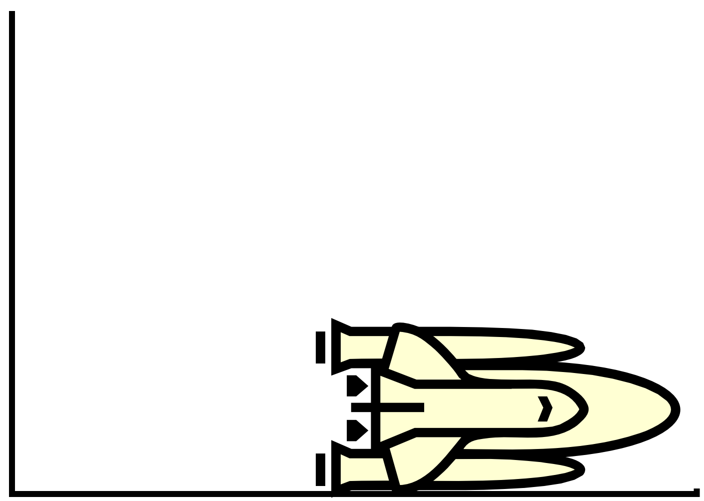
Part 3: Newton's Approach



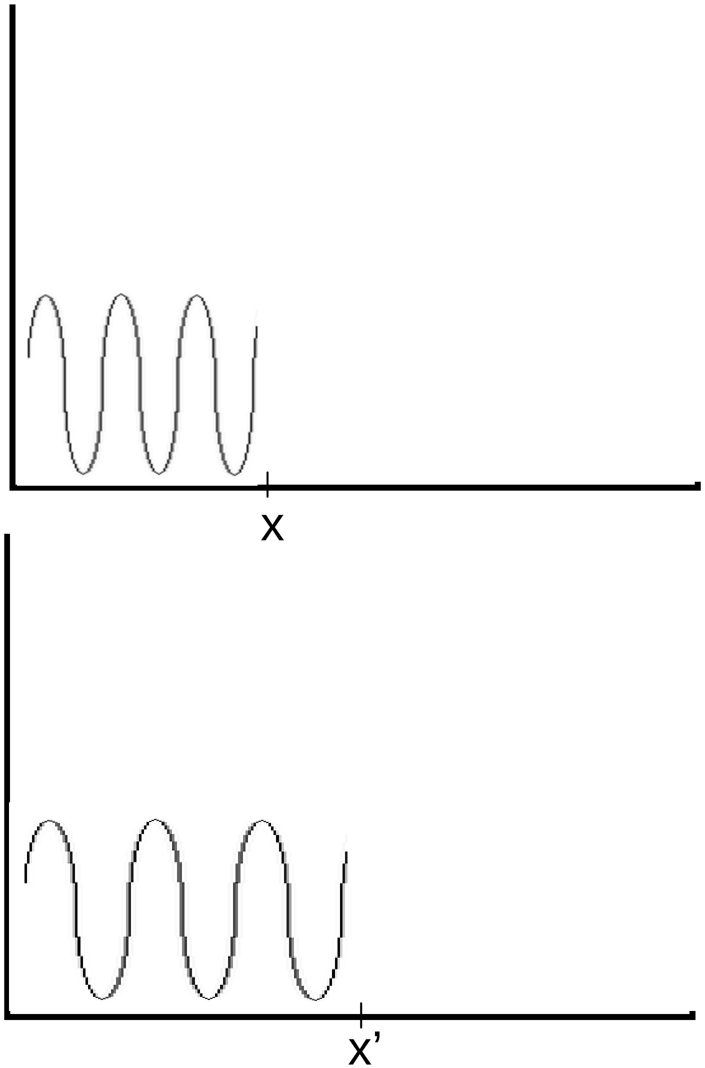


Newton answered the question:
How does position change with the application of velocity and the passage of time?

Key Points

- Newton's equations are **Translation** equations
- They apply to points
- They are <u>not applicable</u> for things that oscillate, such as wavelengths and frequencies
- Mathematically performed using *addition* and *subtraction* such as given by $x = x' + vt$
- Used to change static Measures: 10 miles becomes 15 miles.

Part 3: Lorentz's Approach

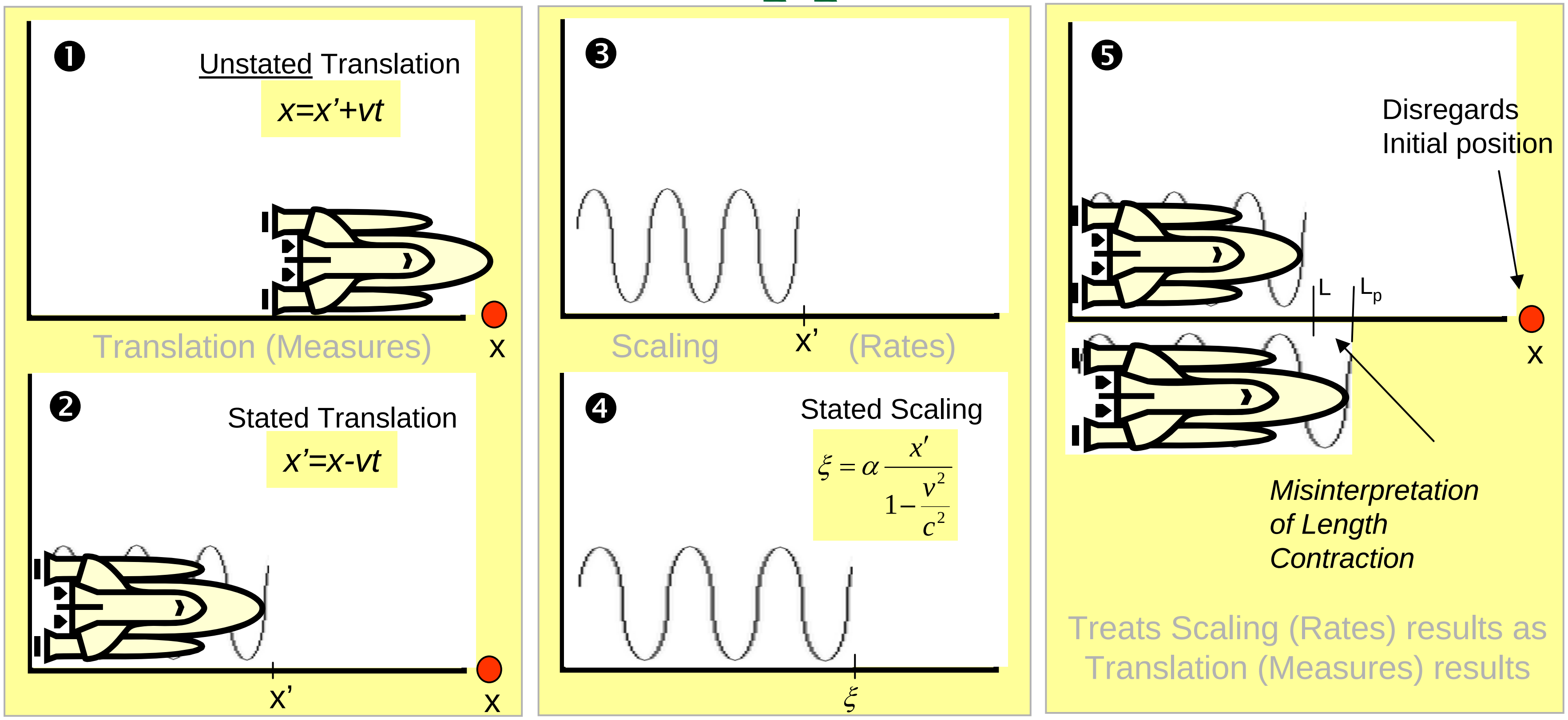


Lorentz answered the question:
How does something that oscillates, such as Frequency or Wavelength, change with the application of velocity?

Key Points

- Lorentz's equations are **Scaling** equations
- Lorentz's equations are <u>not applicable</u> for points
- Mathematically performed using *multiplication* and *division* such as given by $x' = x\beta$
- Used to change Rates: 10 meters per cycle becomes 15 meters per cycle.

Part 3: Einstein's Approach

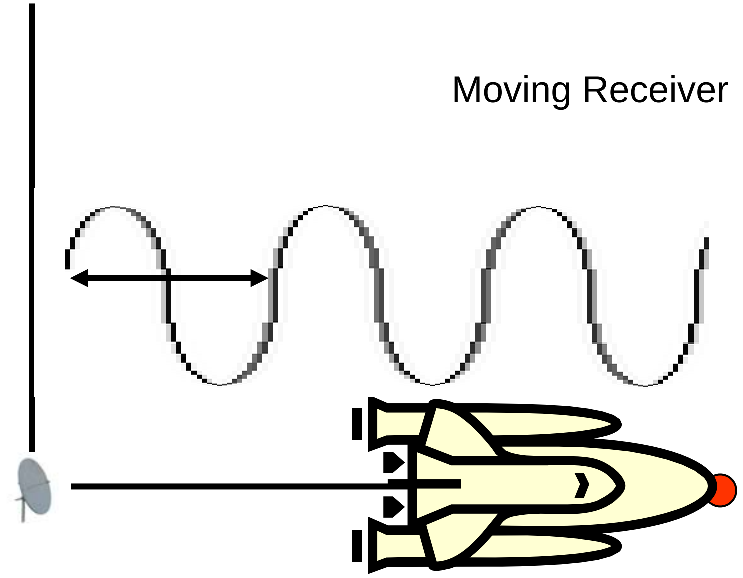


Key Points

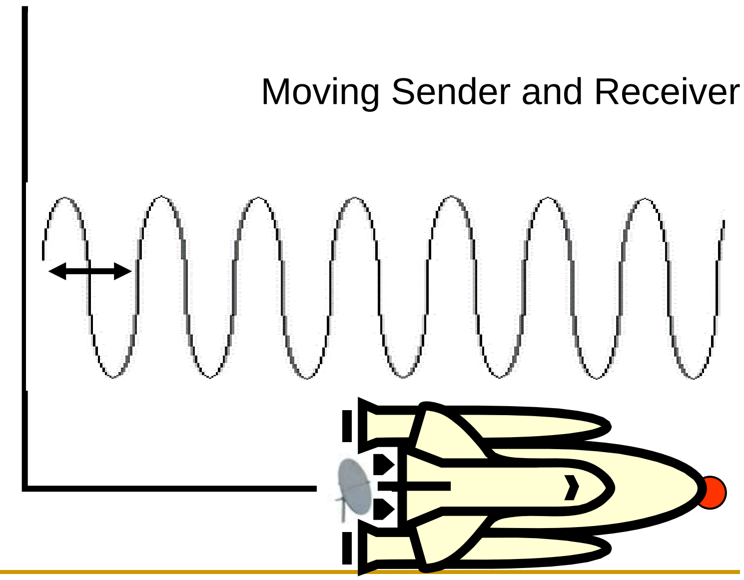
- "Scales" wavelength (which Einstein calls a "moving rod")
- Since Einstein "Postulates" that Frequency (and Wavelength) do not change, the observations are instead explained as Time Dilation and Length Contraction
- Confuses Static Measures (Length) and Rates (Wavelength)
- Einstein does not explain the use of the Newtonian Translation, x-vt, in the derivation

Part 3: Time Dilation

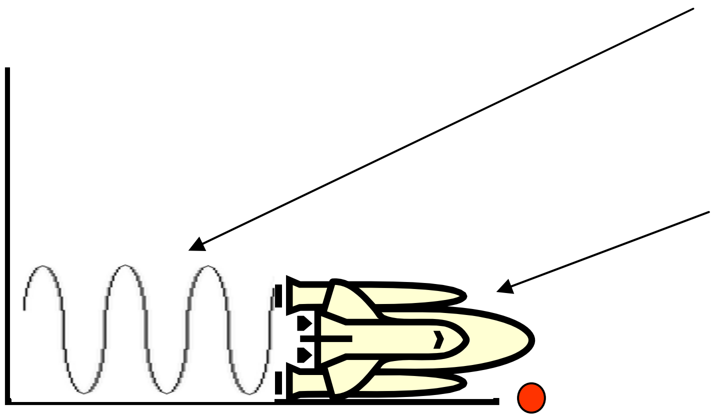
- **Moving Receiver**
  - Wavelength “received” by the receiver is longer (or shorter) than original
  - Time to complete one wavelength is longer
  - Time change is NOT interpreted as Time Dilation.
    - Time does not change
    - Frequency changes



- **Moving Sender and Receiver**
  - Wavelength “received” by the receiver is slightly longer than original
  - Time to complete one wavelength is longer
  - Time change IS interpreted as Time Dilation
    - Frequency is “postulated” as being constant
    - Time must change, as a result



Part 3: CICS Equations



- The **Scaling** equations describe what is going on with the frequency or wavelength based phenomena in an ICS
- The **Translation** equations describe the position of the non-oscillating phenomena (e.g., the spacecraft)

Key Points

- Recognizes the role of Translation for non-wavelength based moving phenomena
- Recognizes the role of Scaling for wavelength (or frequency) based moving phenomena
- Maintains the Frequency and Wavelength Units the mathematical derivation
- Corresponds to MMX and Ives-Stillwell. Should correspond with other frequency or wavelength based experiments
- Does not introduces Time Dilation or Length Contraction (or their associated paradoxes)
- Makes explicit the use of waves in both directions in the derivation (bi-directional)

Part 3: Wavelength in Moving Systems Comparison

The CICS Model is different from Lorentz and Einstein by recognizing that there are two types of main Transformation at work, Frequency changes, and Wavelength is mathematically treated similar to Frequency.

		Newton	Michelson and Morley	Lorentz	Einstein	CICS
Transformation	**Position (Translation)**	Yes	No	No	Yes (Scaling mistaken as a translation transformation)	**Yes** (Newtonian Equations)
Transformation	**Wavelength (Scaling)**	No	Yes	Yes (Not recognized as being this type of transformation)	No* (Yes, but not recognized as this transformation)	**Yes** (ICS Equations)
Interpretation	**Frequency**	N/A	Varies	Unchanged	Unchanged	**Varies**
Interpretation	**Actual Time**	Unchanged	Unchanged	Dilated*	Dilated	**Unchanged**
Interpretation	**Physical Length**	N/A	Unchanged (Wavelength Varies)	Contracted	Contracted*	**Unchanged** (Wavelength Varies)
Mathematics	**Conceptual Formation**	N/A	Bi-Directional	Bi-Directional is Used then Ignored	Bi-Directional is Used then Ignored	**Bi-Directional**
Mathematics	**Wavelength Mathematics**	N/A	Summed	Summed (Normalization Fix)	Summed (Normalization Fix)	**Averaged** (Maintains Units)
Mathematics	**Accuracy For Freq. Based Experiments**	Poor (Does not address oscillating phenomena)	Poor	Good (Not statistically supported for Michelson-Morley)	Good (Not statistically supported for Michelson-Morley)	**Good / Better** (Smallest error for Michelson-Morley and Ives-Stillwell)

Part 3: Summary

- Characteristics of moving, non-oscillating, phenomena (e.g., the spacecraft)
  - Used for Measures
  - Uses Translation Transformations – Answers the question of Position
  - Newtonian Transformations
  - Einstein refers to this “static” length as “Stationary Rods”
- Characteristics of moving, oscillating, phenomena (e.g., waves)
  - Uses Scaling Transformations – Answers the question of Frequency Change
  - Addressed by Lorentz, Einstein – Assumes Frequency is fixed
    - Length Contraction and Time Dilation
    - Einstein produces a Scaling Transformation and mistreats it as a Translation Transformation
  - Addressed by CICS Model – Assumes Frequency changes
    - No need for Length Contraction or Time Dilation
  - Einstein refers to this wavelength as “Moving Rods”
- CICS Model Characteristics
  - Uses both Translation and Scaling Transformation Equations
  - CICS Model accounts for “Standardized Units” for Wavelength and Frequency in Hertz
  - Experiments still make sense, but with a different interpretation since Frequency varies in a moving system

Relativity Challenge

Thank You

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