

School of Basic and Applied Sciences

Course Code : MSCP6001

Course Name: ELECTRODYNAMICS

Electrodynamics

Topic Covered

- Relativity Summary
- Velocity addition
- Relativistic Doppler shift
- Simultaneity
- Causality
- References

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Program Name: M.Sc. Physics

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Relativity Summary

- Relativity Postulates
 - Laws of physics the same in all inertial frames
 - Speed of light in vacuum constant
- Consequences
 - Simultaneity not preserved for two different observers
 - **Time dilation:** proper time t_0 as measured by a clock at rest to the inertial observer
 - Always stretched for the moving observer
 - **Length contraction:** proper length l_0 as measured by observer at rest
 - Always contracted for the moving observer
- Corollaries
 - Space and time form a 4-dim continuum
 - There are global space-time frames with respect to which non-accelerated objects move in straight lines at constant velocities (inertial frames)

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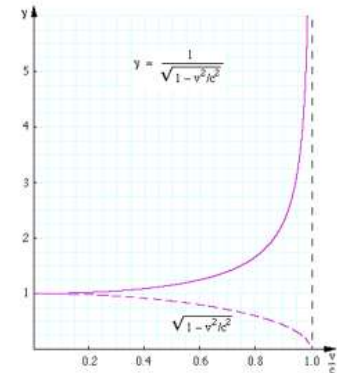
Relativity Summary

Boost Factor

Everything is slowed/contracted by a factor of:

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

in a frame moving with respect to the observer.



Time always runs slower when measured by an observer moving with respect to the clock.

The length of an object is always shorter when viewed by an observer who is moving with respect to the object.

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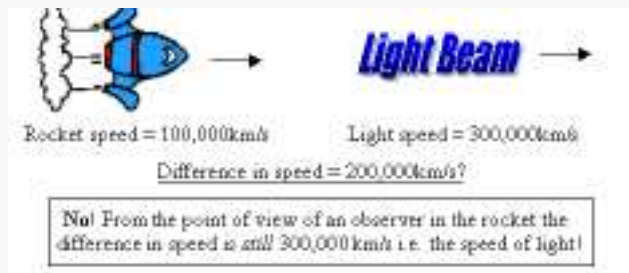
Course Code : MSCP6001

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Velocity addition

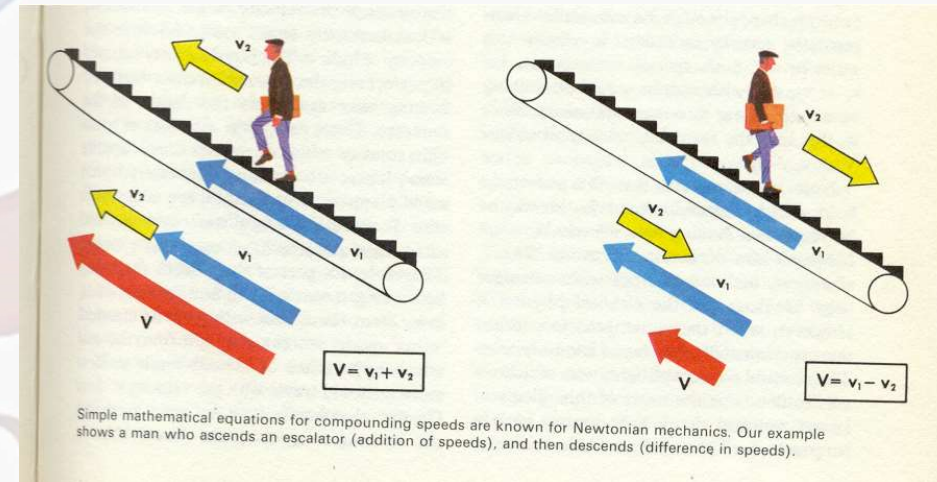
Relativistic

$$V \neq v_1 + v_2$$



$$V = \frac{v_1 + v_2}{1 + v_1 v_2 / c^2}$$

Classical



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Relativistic Doppler shift

Classical red or blue shift formula for non relativistic speeds $v/c \ll 1$

Shift completely due to bunching up (approach) or stretching (recession) of wave crests due to the relative source-observer motion

$$z \equiv \frac{\lambda_{obs} - \lambda_0}{\lambda_0} = v/c$$

Relativistic shift includes also the effect of time dilation. Frequency of light waves specifies how many times the em field oscillates per second in its rest frame $\rightarrow \nu_0, \lambda_0$. The clock of a moving source runs slow and as a result the emission frequency is reduced as measured by the observer. Time dilation always gives a redshift

Relativistic Doppler formula

$$z + 1 = \sqrt{\frac{1 + v/c}{1 - v/c}}$$

Relativistic Doppler has also a small shift in the perpendicular direction of motion

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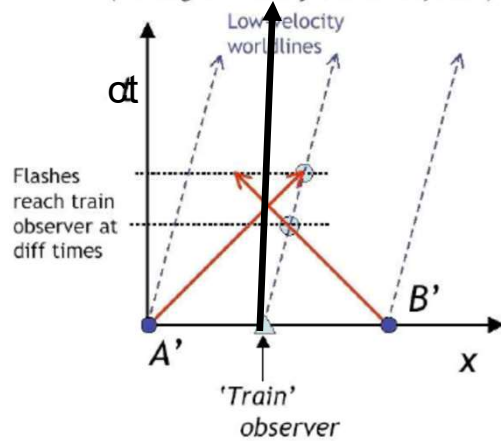
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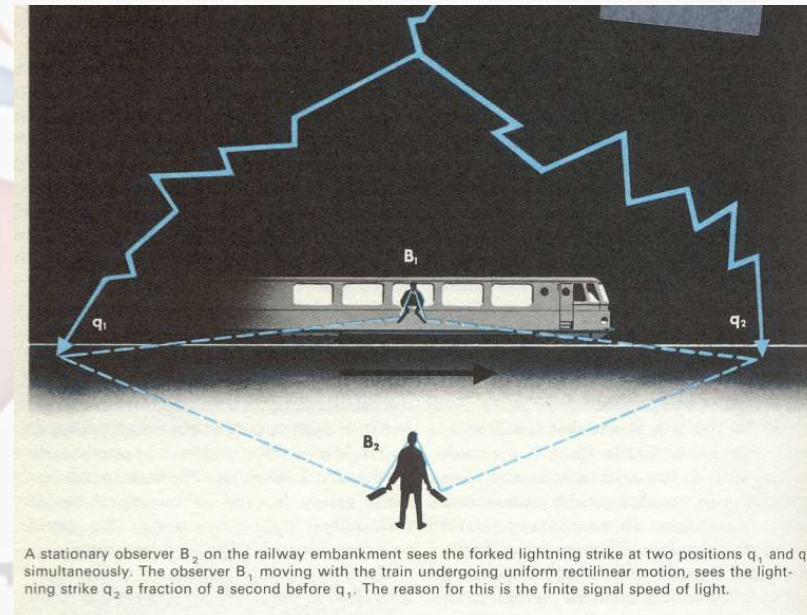
Simultaneity

Simultaneous events in moving frame.

World lines of objects stationary on the train (moving at velocity v in track frame)



Events A' and B' are **not simultaneous**
 $t_{B'} \neq t_{A'}$



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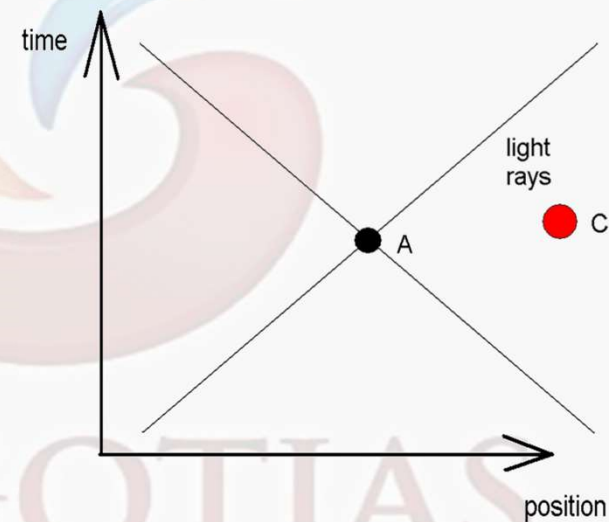
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Causality

- Events **A** and **B**...
 - **Cannot** change order of **A** and **B** by changing frames of reference.
 - **A** can also communicate information to **B** by sending a signal at, or less than, the speed of light.
 - This means that **A** and **B** are causally-connected.
- Events **A** and **C**...
 - **Can** change the order of **A** and **C** by changing frame of reference.
 - If there were any communication between **A** and **C**, it would have to happen at a speed faster than the speed of light.
- If idea of **cause and effect** is to have any meaning, we must conclude that no communication can occur at a speed faster than the speed of light.



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References

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