Imperial College London

Relativity – Lecture 2

Dr Caroline Clewley

Key points of Lecture 1

- Maxwell's equations imply a speed of light that is independent of the speed of the light source;
- 19th Century experiments tried to determine the state of the 'ether' – the proposed medium for light waves;
- Einstein explains the conflicting results of the Fizeau experiment and the famous Michelson-Morley null-result by proposing there is no ether.

1905: Einstein's Special Relativity postulates

1. The laws of physics are the same in all inertial reference frames.

2. The speed of light is independent of the speed of the source or observer.

2b. The speed of light in vacuum is constant in all inertial frames.

What is an inertial frame?

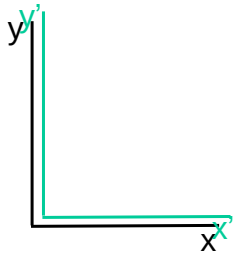
An inertial frame is a frame in which isolated bodies move uniformly.

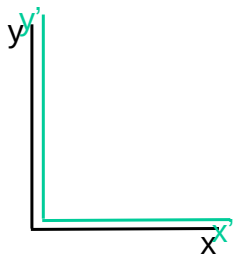
An inertial frame is a frame in which the law of inertia holds.

Examples of inertial frames

Examples of inertial frames

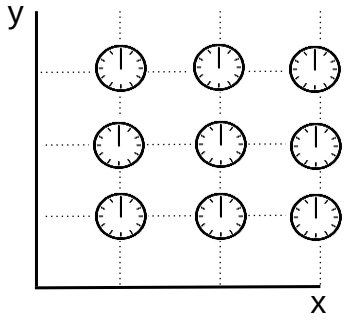
Reference frame





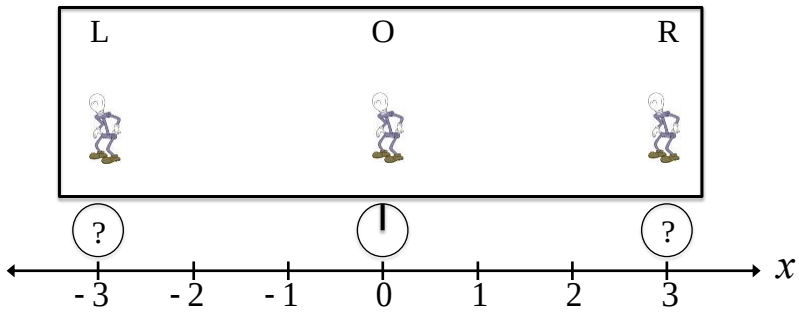
Observers

Each reference frame contains an infinite number of observers with synchronised clocks who know their position.



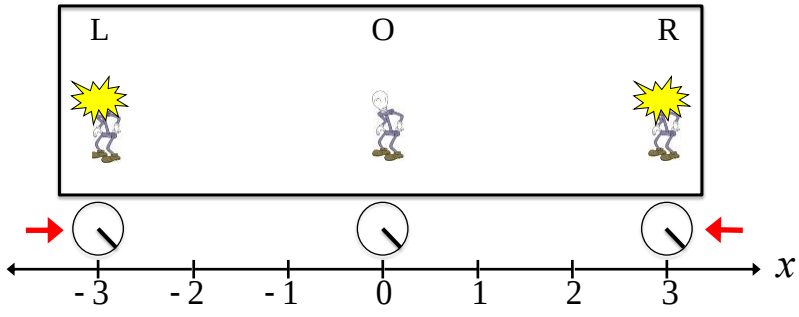
Synchronised clocks

Oscar sits at the origin of reference frame *S* ($x = 0$).
Meter sticks establish distances in *S*.
Local observers at $x = -3\ \text{m}$ (Lucy) & $x = +3\ \text{m}$ (Ricky).
Procedure to synchronize all clocks in *S* ?



Procedure to synchronize all clocks in frame *S*

Oscar emits a light flash at $t = 0$.
Light spreads outwards in a spherical wavefront.
At $\Delta t = (+3\ \text{m})/c$ the wavefront reaches Lucy and Ricky.



Lucy & Ricky know to set their clocks to $t = (0 + 3\ \text{m})/c$!

Events

Observers record events which happen at a particular position *and* a particular *time* (t,x,y,z) or (t’,x’,y’,z’).

Proof of postulate 2b

The laws of physics are the same in all inertial reference frames.

+

The speed of light is independent of the speed of the source or observer.

=

The speed of light in vacuum is constant in all inertial frames.

Proof of postulate 2b

Alvager experiment (1964) confirms *c* is constant