LECTURE 23 & 24 : Special Relativity

At the end of these lectures you should:

- Understand "*frame of reference*" and "*inertial frame of reference*".
- Know that the velocity of light is invariant.
- State Einstein's postulates on which Special Relativity is based.
- Understand "*time dilation*" and be able to perform simple calculations.
- Understand "*length contraction*" and be able to perform simple calculations.
- Understand Einstein's equation $E = mc^2$ and be able to perform calculations using this equation.
- Understand and use relativistic equations for total energy and kinetic energy.

Special Relativity

- Einstein
- Challenged and changed our concepts of space and time
- Experimentally proven

Frame of reference

A place with respect to which measurements are made eg

Inertial frame of reference

One in which Newton's Laws hold

How would you know if you were in a frame of reference which is accelerating with respect to an inertial frame?

Classical Relativity

Consider someone on a train throwing a ball :

a) horizontally

b) vertically upwards

as measured by an observer in the train and an observer at the station

Ball thrown horizontally

What the observer on the train sees:

He/she sees the ball moving horizontally at v_{bt} (the speed relative to the train).

What the observer at the station sees:

He/she sees the ball moving horizontally at

$v_{bs} = v_{bt} + v_{ts}$

where v_{ts} is the speed of train relative to station

Ball thrown vertically

What the observer on the train sees:

He/she sees the ball moving vertically up and down

What the observer at the station sees:

He/she sees the ball moving in a parabola. The horizontal speed is v_{ts} . The vertical motion is just motion under gravity.

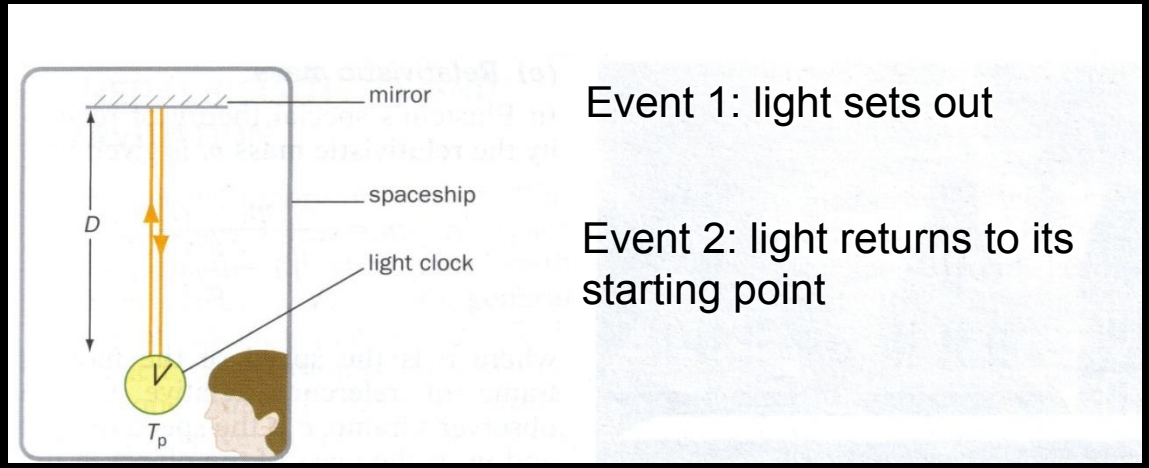
What are Einstein's postulates?

Einstein's postulates

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

2 The velocity of light (in a vacuum) is the same in all frames of reference

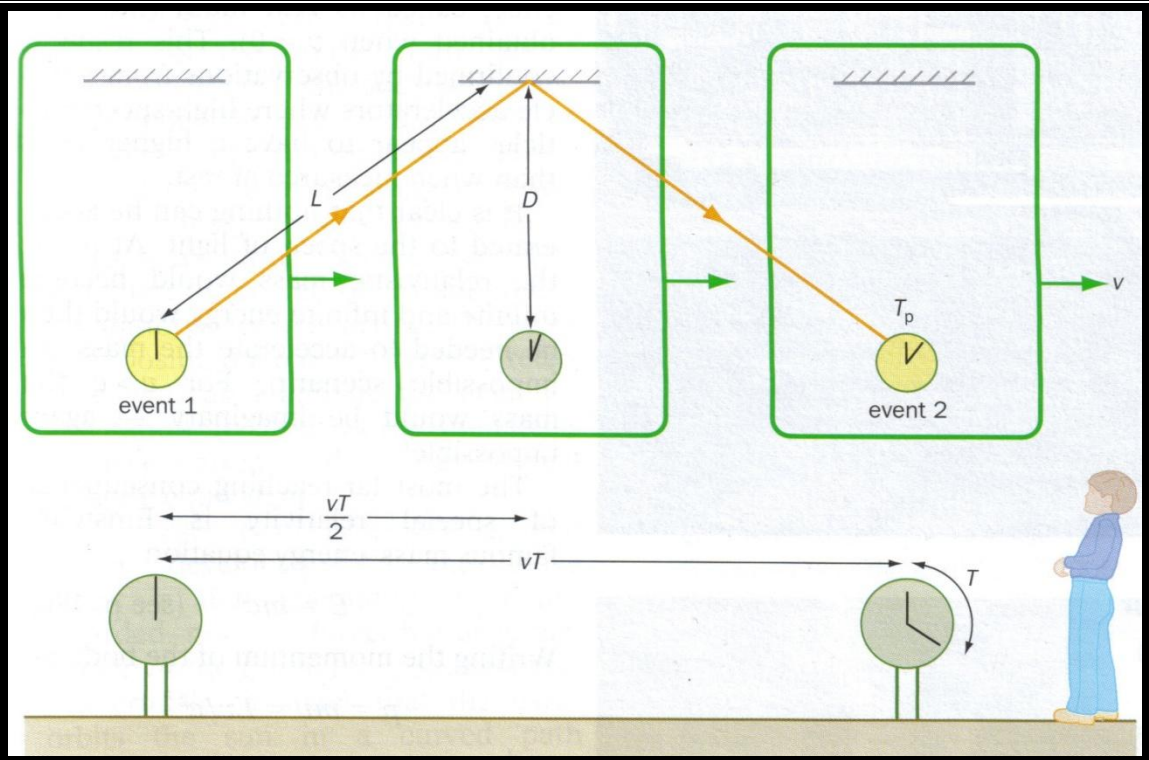
and is thus independent of the motion of the light source or the observer.



Event 1: light sets out

Event 2: light returns to its starting point

Zoe in the spaceship measures time between 2 events in the spaceship



Adam on the Earth measures time between same 2 events

Zoe: Proper Time

(Events in same place)

Adam: Measures time interval between events in different places. (Measures time intervals between events on a moving frame of reference).

Time Dilation

- **Proper time** This is when only one clock is required to measure the time interval between two events that occur at the same place in that frame of reference (Zoe's frame)

- Time measured by Adam is "slower" or "dilated" compared with time measured in a frame of reference (Zoe's) which is moving with respect to Adam's frame of reference.

Time dilation

The time interval between two events is shortest in a frame of reference in which the events occur at the same place.

Example 1

A spaceship completes a one-way journey that takes 25 years according to observers on Earth. If the spaceship travels at 0.95c relative to Earth, how long does an astronaut on board the spaceship consider the journey to take?

Example 2

A stationary muon decays in 2.2 μs. What is its lifetime as observed from a laboratory on Earth if the muon is moving at 0.97c relative to Earth? How far does it travel in this time?

(This situation provides experimental evidence for time dilation).

LECTURE : CHECK LIST

READING Adams and Allday: 8.23, 3.19, 8.24,8.25

At the end of these lectures you should

- Understand the concepts of *frame of reference* and *inertial frame of reference*.
- Know that the velocity of light is invariant.
- State Einstein's postulates on which Special Relativity is based
- Understand what is meant by *time dilation* and be able to perform simple calculations.
- Understand what is meant by *length contraction* and be able to perform simple calculations.
- Understand Einstein's equation $E = mc^2$ and be able to perform calculations using this equation.
- Understand and use relativistic equations for total energy and kinetic energy.

Additional Materials

- Check out the websites at:
- http://www.phys.unsw.edu.au/einsteinlight/jw/module4_time_dilation.htm
- http://www.youtube.com/watch?v=xNB7KEg9siM&feature=results_video&playnext=1&list=PLC560B8892351ACAF
- http://www.squidoo.com/relativity_explanation
- http://www.youtube.com/watch?v=ev9zrt__lec