PHYSICS
PAPER-6 (SSE 611)
Special and General theory of relativity, Statistical mechanics, Wave mechanics and Nano physics

Programs	B.Sc
Subject	Physics
Semester	V
University	Kuvempu university
Session	04

Special theory of relativity

Topics Covered:

- Concept of Length contraction and
- Concept of Time dilation

Recap of Previous Session:

1. Lorentz transformation equations.
2. Velocity of light.

Learning objectives

After the study of this session the students should be able to understand

- Explanation of proper length and relative length.
- Calculation of length contraction.
- Explanation of proper time interval and relative time interval.
- Concept of twin paradox

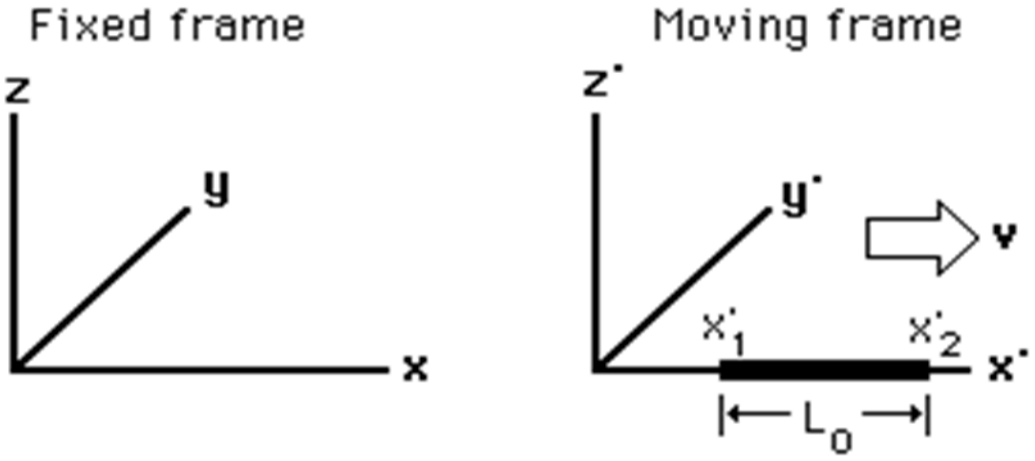
Session outcomes:

- The contraction becomes appreciable when velocity of rod (v) is nearly equal to velocity of light c.
- The velocity of the rod is equal to or greater than c, then the length of the rod becomes zero.
- Time dilation: when two objects moving relative to each other experiences a different rate of time flow.

Proper length: It is the distance between the two points measured by an observer who is at rest relative to both the points.

Proper time: the time measured by an observer at rest relative to the event being observed.

Length contraction: it is the shortening of measured length of an object moving relative to the observer's frame.



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If two inertial frames S and S^I are in relative motion as that S^I moves with a uniform velocity 'v' to the right along the X axis relative to S. length of an object depends upon the velocity of the observer w.r.t to the object

For S^I , the length of an object is

$$AB = x_2^I - x_1^I = L_0$$

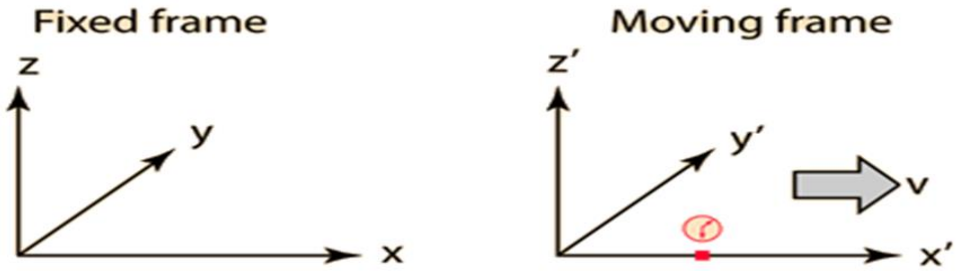
For S, the length of an object is

$$AB = x_2 - x_1 = L$$

by using Lorentz transformation equation we get

$$L = L_0 (1 - v^2/c^2)^{1/2}$$

Time dilation: A clock in the frame appears to go slow to an observer in the frame S^{I} who is motion with respect to the frame S.



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The clock in the frame S, the observer 'O' in the frame S keep his clock at a fixed point X_1 measure the time interval $T_0=t_2-t_1$

Let the observer O^{I} in the inertial frame of reference S^{I} between the same two events be t_1^{I} and t_2^{I}

According to Lorentz transformation, time dilation is given by

$$T = \frac{T_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

Summary of the session:

- Length contraction.
- Proper length.
- Contraction factor
- Time Dilation.
- Proper Time.
- Dilation Factor.

MCQs

1) Clocks in a moving reference frame, compared to identical clocks in a stationary reference frame, it appears to run

a) Slower
b) Faster
c) At the same rate
d) Backward in time

Answer: a) Slower

2) **If two identical clocks, one clock is placed on surface of the planet and other clock is placed in interstellar space, which runs faster**

a) Space clock
b) Planet clock
c) Both the clock runs at the same rate
d) None of the above

Answer: a) Space clock

3) **An object moving at a relativistic speed in a stationary observer appears to**

a) have length expanded and have a faster clock.
b) have length expanded and have a slower clock.
c) have length contracted and have a faster clock.
d) have length contracted and have a slower clock.

Answer: d) have length contracted and have a slower clock.

4) **When does length contraction affect an object**

a) Only when it is moving at speed nearer to the speed of light.
b) Only at slow speeds.
c) All times when it is moving.
d) When it is not moving.

Answer: a) Only when it is moving at speed nearer to the speed of light.

5) Length contraction states that an object shrinks in what direction?

a) The same as its movement.
b) All directions at once.
c) The direction perpendicular to its movement.
d) Towards the object's center of mass.

Answer : a) The same as its movement.

References:

- Arthur I. Miller “ Albert Einstein’s Special theory of relativity”
- Robert W. Lawson “The special and General theory” -1920
- C L Arora and Dr. P S Hemne “ physics for degree students”
- R Murugeshan, Kiruthiga Shivaprasath Modern physics
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