

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	03

Special theory of relativity

Topics Covered:

- Significance of null result of Michelson-Morley experiment.
- Postulates of Einstein special theory of relativity.
- Lorentz transformation equations.

Recap of Previous Session:

- Non existence of ether medium.
- At different time and at different places the fringe shift observed in Michelson-Morley experiment is same.

Learning objectives

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

- Ether medium does not exist.
- It is impossible to measure the speed of earth relative to the ether.
- Space, time, mass, simultaneity, motion etc., are not absolute but relative, absolute to frame of reference.
- Both Lorentz transformation and inverse transformation equations.

Session outcomes:

- Null result of Michelson-Morley Experiment.
- The effect of ether undetectable.
- All natural events are unaffected by uniform motion.
- It is impossible to determine absolute motion by any experiment.
- Lorentz transformation equations.

Comment on Null result Of Michelson-Morley

Experiment:

- Michelson explain the null result –the earth dragged the ether along with it.
- There was no relative motion between the earth and ether.
- No change in velocity of light was observed and this is known as null result.

Postulates of theory of relativity:

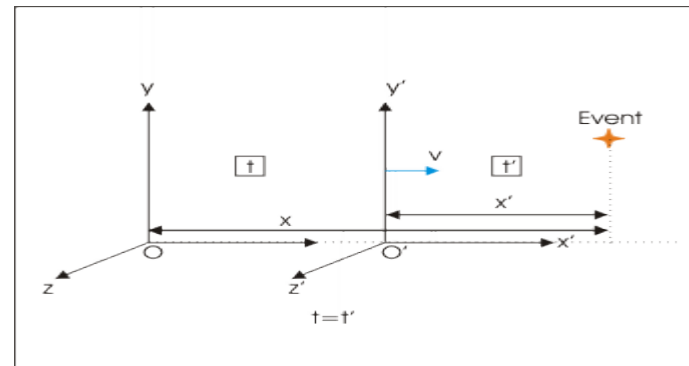
- **First postulate:** The laws of physics are same in all inertial frames of reference.
- **Second postulate:** The velocity of light in free space is constant. It is independent of the relative motion of the source and the observer

Lorentz transformation equations:

- S and S' be two inertial frames.
- When frame S' is moves with uniform velocity ' v ' relative to other frame S along positive X -direction.
- The event described by the observer O are (x,y,z,t) .
- The coordinates of the same event described by the observer O' are (x',y',z',t') .
- After the time ' t ' as measured by O the origin of the system S' is at a distance ' vt ' from the origin of the system is given by

$$x' = x - vt$$

Relative motion between S' and S is at right angles to Y and Z axis, the position coordinates is $y' = y$ & $z' = z$



The two observers O and O' will compute the same time, then $t = t'$

The Lorentz transformation equations are:

$$\begin{aligned}x' &= \frac{x - vt}{\sqrt{1 - \frac{v^2}{c^2}}} \\y' &= y \\z' &= z \\t' &= \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}\end{aligned}$$

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Inverse Lorentz transformation equations

$$x = \frac{x' + vt'}{\sqrt{1 - v^2/c^2}}, y = y', z = z'$$

$$t = \frac{t' + vx'/c^2}{\sqrt{1 - v^2/c^2}}$$

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Summary of the session:

- Null Result of Michelson-Morley Experiment.
- Postulates of Special theory of relativity.
- Lorentz transformation equations.

MCQs

1) Which of the following is a postulate of special relativity

- a) The laws of physics are the same for all observers in uniformly moving frames of reference
- b) The relative speed of two objects is the same for all observers
- c) The wavelength of light is the same for all observers
- d) None of the above

Answer: a) The laws of physics are the same for all observers in uniformly moving frames of reference

2) Einstein's Second Postulate of Special Relativity states that the speed of light

- a) can increase if the speed of the light source increases
- b) is constant regardless of the speed of the observer
- c) can decrease if the speed of the observer decreases
- d) it changes depending upon its light source

Answer: b) is constant regardless of the speed of the observer

3) If $v \ll c$, Lorentz transformation is the same as

- a) Einstein's transformation
- b) Planck's transformation
- c) Galilean transformation
- d) Maxwell's transformation

Answer: c) Galilean transformation

4) Lorentz transformation is based on the principle of consistency of velocity of light

a) True

b) False

Answer: a) True

5) If two are simultaneous for one observer, they will be simultaneous for all other observers as well.

a) True

b) False

Answer: a) True

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 Murugesan, Kiruthiga Shivaprasath Modern physics