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	05

Special theory of relativity

Topics Covered:

- ➢Relativity of simultaneity and
- ➢Velocity addition theorem.

Recap of Previous Session:

- Lorentz transformation equations
- Length contraction.
- Time Dilation.

Learning objectives

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

- Describes simultaneity is a relative concept for observers in different inertial frames in relative motion.
- Derivation of velocity addition formula.

Session outcomes:

- Two events measured as simultaneous in one inertial frame are not necessarily simultaneous in all inertial frames.
- Velocity of light is the maximum attainable velocity-Relativistic velocity addition theorem.

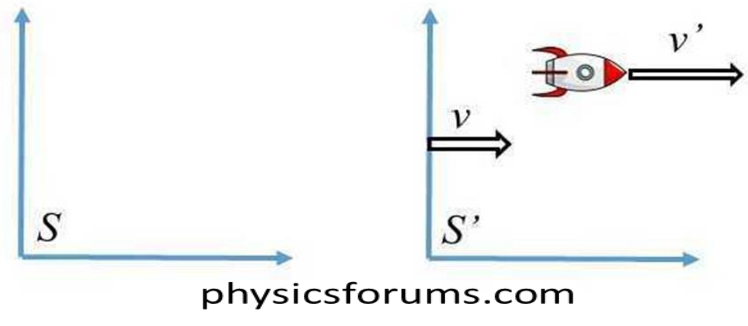
Prerequisites:

- Lorentz transformation.
- Concept of space-time.
- Relativistic speed.

Relativistic velocity addition:

- The Lorentz transformation equation enable us to transform the velocity from one frame to reference to another, in relative motion with respect to it and lead to a relativistic formula for the addition of velocities is known as velocity addition theorem.
- Relativistic velocity addition formula describes the velocities of an object moving at a relativistic speed

  Let S and S^l be two inertial frames in relative motion, so that S^l moves with a uniform velocity 'v '

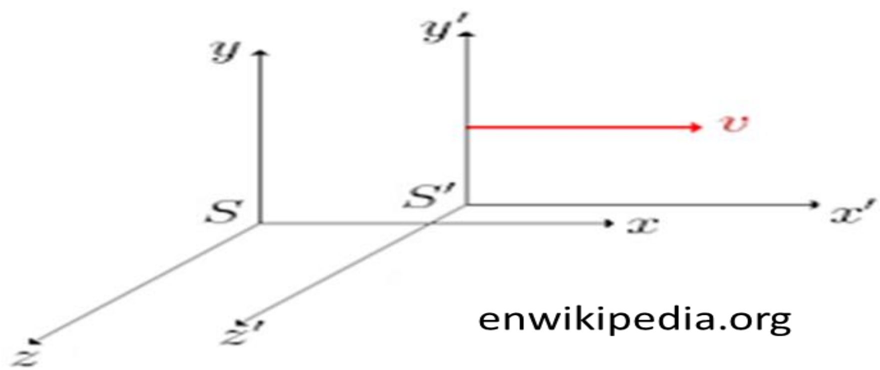


Let U and U^{l} be the velocities of a particle respectively measured in the inertial frames S and S^{l} , By using Lorentz transformation equation ,we get

$$U= U^{l} + v / (1+U^{l} \ v/c^{2})$$

Relativity of simultaneity:

This is the important consequence of Lorentz transformations . If any two events occurring simultaneously at different places in one frame of reference will not appear to be simultaneous in another frame of reference. This means simultaneity is



enwikipedia.org

- The concept of simultaneity has only a relative and not an absolute meaning.
- Consider two events characterised by the space and time coordinates (x_1,y_1,z_1,t_1) and (x_2,y_2,z_2,t_2) in the frame S and by (x'_1,y'_1,z'_1,t'_1) and (x'_2,y'_2,z'_2,t'_2) in the frame S' . The frame S' is moving with a velocity relative to S along +X axis.
- By using the time co-ordinates of two events are connected by Lorentz transformations

$$t_2' - t_1' = 1/(1-v^2/c^2)^{1/2}\,[(t_2 - t_1) - v/c^2 \quad (x_2 - x_1)]$$

$$v<c, \quad 1/c\,(x_2-x_1)>(t_2-t_1)$$

$$(x_2-x_1)>c(t_2-t_1)$$

But this is not possible, as no signal can travel with velocity greater than that of light. Hence the order of events shall remain the same in both the inertial frames.

MCQs

1) Two photons approach each other, what is their relative velocity

a) 2c
b) C
c) 3c
d) c/2

Answer: b) C

2) A rocket is sent with a velocity 0.9c. A light is also sent along the same path. What is the velocity of the light pulse relative to the rocket?

a) 3/2 c
b) 2c
c) C
d) 9c

Answer: c) C

3)The term simultaneity events are

a) Same frame of reference.
b) At the same time in different frame of reference.
c) At the same time in the same frame of reference.
d) All the above.

Answer: c) At the same time in the same frame of reference.

4)If a clock moving along with S' frame with a velocity 0.9c shows an interval of 1 hr, how much time might have elapsed in frame S at rest on earth?

a) 1hr 3min

b) 3hr 2min

c) 3hr 12min

d)3hr 9min

Answer: c) 3hr 12min

5) Two space crafts A and B are moving away from earth in the same direction with speed 0.8c and 0.6c respectively. Find velocity of B with respect to A ?

a) 3.8c
b) 0.38c
c) -3.8c
d) -0.38c

Answer: c) -0.38c

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