## STR Tutorial-1

Lorentz Transformation

Q1. Let (x,t) and (x',t') be the coordinate system used by the observers o and o' moves with a velocity $v = \beta c$ along their Common Positive x axis. If $x_+ = x + ct$ and $x_- = x - ct$ are the linear Combinations of the Coordinates.

Write down expression of x'_+ as function of $f(x_+, \beta)$ and x'_- as function of $f(x_-, \beta)$.

Q2. Two events separated by a (spatial) distance $9 \times 10^9 m$, are simultaneous in one inertial frame. Find the time interval between these two events in a frame moving with a constant speed $0.8\ c$ (where the speed of light $3 \times 10^8 m/\sec$).

Q3. In a certain inertial frame, two light pulses are emitted at point $5km$ apart and separated in time by $5\mu\sec$. An observer moving at a speed v along the line joining these points notes that the pulses are simultaneous. Find the speed of observer.

Relative Speed

Q4. Observer 1 sees a particle moving with velocity v on a straight line trajectory inclined at an angle θ to his z axis. Observer 1 is moving with velocity $u\hat{k}$ relative to observer 2. derive the formulas for the velocity and direction of motion of particle as by seen observer 2. check that you get the proper result in the limit $v \to c$

Q5. In a Lab frame, particles A and B moves with speed u and v along the paths shown in figure. The angle between the trajectories is θ. What is speed of one particle as viewed by the other?
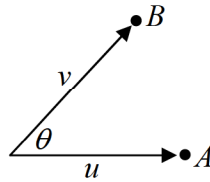
Length Contraction

Q6. A rod of proper length l_0 oriented parallel to x axis moves with speed u along the x axis in S frame .if S' frame is moving with speed v along x axis .prove that length measured from S' frame is $l_0 \dfrac{\sqrt{(c^2 - v^2)(c^2 - u^2)}}{c^2 - uv}$

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Q7. A shooter fires a bullet with velocity u in the $\hat{x}$ direction at a target. The target is moving with velocity v in the $\hat{x}$ direction relative to the shooter and is at a distance L from him at the instant the bullet is fired. If $\gamma_1 = \dfrac{1}{\sqrt{1 - v^2/c^2}}$ and $\gamma_2 = \dfrac{1}{\sqrt{1 - u^2/c^2}}$

(a) Find the time taken by the bullet to hit the target in the target's frame of reference is

(b) The time taken by the bullet to hit the target in the bullet's frame of reference is

Time dilation

Q8. The Pions can be produced by bombarding a suitable target in an acceleration with high energy protons, the Pions leaving the target with speed $0.99c$. It is found that pions is radioactive elements and its half life is 1.77×10^{-8} sec.

(a) Find the distance travel by the Pions till its intensity become half of initial intensity.

(b) With the result find in question a) prove that half life is 1.77×10^{-8} sec

Q9. Two spaceships A and B are moving with speed $0.6c$ with respect to earth. Both the spaceships are moving in opposite directions. Space ship A emits light which will appear one year after to an observer attached to the earth. After what time Same light pulse will appear to an observer attached to space ship B.

Loss of Simultaneity

Q10. Two trains, A and B, each have proper length L and move in the opposite direction. A's speed is $4c/5$, and B's speed is $3c/5$. A starts behind B (see Figure).
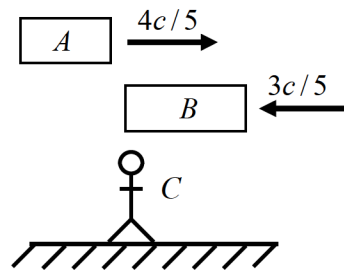
(a) How long, as viewed by person C on the ground, does it take for A to overtake B?

(b) How long as viewed by a Person standing on B such that A to overtake B?

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