PH111: Tutorial Sheet 6

This tutorial sheet deals with problems related to the special theory of relativity.

1. The time interval between two ticks of two identical clocks is 2.0 sec. One of the two clocks is set in motion, so that its speed relative to the observer, who holds the other clock is $0.6c$. What is the time interval between the ticks of the moving clock as measured by the observer with the stationary clock?

2. The incoming primary cosmic rays create μ-mesons in the upper atmosphere. The lifetime of μ-mesons at rest is 2 μs. If the mean speed of μ-mesons is $0.998c$, what fraction of the mu-mesons created at a height of 20 km reach the sea level?

3. Two observers A and B are close to a point where lightning strikes the earth. According to A, a second lightning strikes t_0 seconds later at a distance d from him. B, on the other hand finds the two events to be simultaneous. Find his velocity with respect to A. Also find the distance between the two lightnings as seen by B. Assume earth to be inertial frame of reference.

4. Observer A is at rest in frame S' moving horizontally past an inertial frame S at a speed of $0.6c$. A boy in the frame S, drops a ball, which according to the clock of observer A, falls for 1.5sec. How long will the ball fall for an observer at rest in S frame ?

5. A meter stick is positioned so that it makes an angle 30^o with the x-axis in its rest frame. Determine its length and its orientation as seen by an observer who is moving along x-axis with a speed of $0.8c$.

6. A rod flies with constant velocity past a mark, which is stationary in reference frame S. In reference frame S, it takes 20 ns for the rod to fly past the mark. In the reference frame S', which is fixed with respect to the rod, the mark moves past the rod for 25 ns. Find the length of the rod in S and S' and the speed of S' with respect to S.

7. A rod of length 60 cm in its rest frame is traveling along its length with a speed of $0.6c$ in the frame S. A particle moving in the opposite direction to the rod, with a speed $0.6c$ in S, passes the rod. How much time will the particle take to cross the rod

   (a) in the frame S.

   (b) in the rest frame of the particle.

8. Two spacehips pass each other, travelling in opposite directions. The speed of ship B, measured by a passenger in ship A is $0.96c$. This passenger has measured the length of the ship A as 100 mt and determines that the ship B is 30 mt long. What are the lengths of the two ships as measured by a passenger in ship B ?

9. An observer O is at the origin of an inertial frame. He notices a vehicle A to pass by him in $+x$ direction with constant speed. At this instant, the watch of the observer O and the watch of the driver of A show time equal to zero. 50 μs after A passed by, O sees another vehicle B pass by him, also in $+x$ direction and again with constant speed. After sometime B catches A and sends a light signal to O, which O receives at 200 μs according to his watch. The driver of B notices that, in his frame, the time between passing O and catching A is 90 μs Assume that drivers A and B are at the origins of their respective frames. Find

(a) the speeds of B and A, in the frame of O.

(b) position of A in O's frame when B passes O.

(c) the position of O in the frame of A, when B passes O.

10. An intertial frame S' moves relative to another frame S with a velocity $v_1\hat{i} + v_2\hat{j}$ in such a way that the x and x' axes, y and y' axes and z and z' axes are always parallel. Let the time $t = t' = 0$ when the origins of the two frames are co-incident. Find the Lorenz transformation relating the co-ordinates and time of S' to those in S.

11. An observer sees two spaceships flying in opposite directions with speeds $0.99c$. What is the speed of one spaceship as viewed by the other?

12. Two identical spaceships, each 200 m long, pass one another traveling in opposite directions. If the relative velocity of the two space ships is $0.58c$: (a) how long does it take for the other ship to pass by as measured by a passenger in one of the ships, and (b) if these spaceships are moving with velocities $\pm u$ with respect to a frame S along the x-direction, what are their lengths as measured by an observer in S.

13. A rod of proper length l is oriented parallel to x-axis in a frame S, and is moving with a speed u along the same direction. Find its length in a frame S' which is moving with a speed v with respect to S, also along the x direction.