PH110: Tutorial Sheet 5

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. A clock is at rest in frame S. In this frame, the time interval between two ticks of the clock is one second. There is an observer in frame S' which moves with speed v with respect to S. This observer measures the time interval between the two ticks of the clock to be two seconds. What is the value of v?

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

4. 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.

5. 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 ?

6. A meter stick is positioned so that it makes an angle 30° 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 $0.8c$.

7. 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 fixed to the rod, S', 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.

8. An astronaut moves away from the earth, travelling with constant velocity. After some time, she discovers a new solar system. According to her, the time of travel is 12 years. But her colleagues on earth measure the time of travel as 17 years.

   (a) What is the speed v of the astronaut? Express your answer as a fraction (v/c).
   (b) What is the distance between the earth and the new solar system? Is it $(v * 12$ years$)$ or $(v * 17$ years$)$? Justify your answer.

9. 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.