Modern Physics

Tutorial 2
Special Relativity
LUMS School of Science and Engineering

September 10, 2012

1 Relativistic Addition of Veocities

The motion of a transparent medium influences the speed of light. This effect was first observed by Fizeau in 1851. Consider a light beam in water. The water moves with speed v in a horizontal pipe. Assume the light travels in the same direction as the water moves.

a) what is the speed of light in the frame of water?

b) what is the speed of light in the lab frame?

2 Lorentz Transformation

Keilah, in reference frame S, measures two events to be simultaneous. Event A occurs at the point (50.0 m, 0, 0) at the instant $9:00:00$ Universal time on January $15, 2010$. Event B occurs at the point (150 m, 0, 0) at the same moment. Torrey, moving past with a velocity of 0.800c i, also observes the two events. In her reference frame $S^{'}$, which event occurred first and what time interval elapsed between the events?

3 Another Proof of Addition of Velocity Formula

Frame $S^{'}$ travels at speed V_1 along the x-axis of frame S (in the standard configuration). Frame $S^{''}$ tavels at spped V_2 along the $x^{'}$ axis of frame $S^{'}$ (also in the standard configuration). By applying the standard Lorentz transformation twice find the coordinates $x^{''}$, $y^{''}$, $z^{''}$, $t^{''}$ of any event in terms of x, y, z, t. Show that this transformation is in fact the standard Lorentz transformation with velocity V given by the relativistic "sum" of V_1 and V_2.

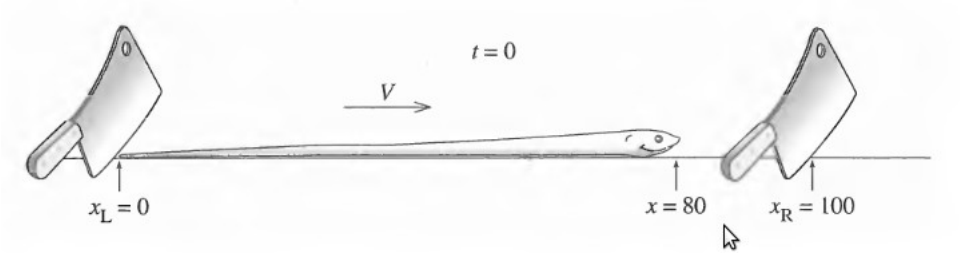

Figure 1: Relativistic Snake Paradox

4 A Relativistic Snake

A relativistic snake, of proper length 100 cm, is traveling across a table at V = 0.6*c*. To tease the snake, a physics student holds two cleavers 100 cm apart and plans to bounce them simultaneously on the table so that the left one lands just behind the snake's tail. The students reasons as follow: "The snake is moving with V = 0.6c, so its length is contracted by a factor $\gamma = \frac{5}{4}$ and its length in my frame is 80 cm. Therefore, the cleaver in my right hand bounces well ahead of the snake, which is unhurt." This scenario is shown in Figure 1. Meanwhile the snake reasons thus: "The cleavers are approaching me at V = 0.6c, so the distance between them is contracted to 80cm, and I shall certainly be cut to pieces when they fall". Use the Lorentz transformation to resolve this paradox.

5 Space-Time Diagrams

Draw the t and x axes of the spacetime coordinates of an observer S and then draw:

(a) The world line of S's clock at x = 1 m.

(b) The world line of a particle moving with velocity dx/dt = 0.1c, and which is at x = 0.5 m when t = 0.

(c)Use the spacetime diagram of an observer S to describe the following experiment performed by S. Two bursts of particles of speed v = 0.5c are emitted from x = 0 at ct = −2 m, one traveling in the positive x direction and the other in the negative x direction. These encounter detectors located at x = ±2m. After a delay of ct = 0.5 m of time, the detectors send signals back to x = 0 at speed v = 0.75c.