

AST 231 Problem Set 1 (Due 5pm 9/19/08 in B&L A231 Locker)

1. 4.2

2. 4.4

3. 4.6

4. 4.9

5. Consider a train and a tunnel which both have the same length when measured in a frame in which there is no relative motion between the two. Now consider that the train moves with constant velocity along a track passing through the tunnel. The train moves near the speed of light and the conductor on the train says: “The tunnel is Lorentz contracted and is shorter than the train, therefore there is no time at which the train is fully within the tunnel.” Meanwhile the tunnel keeper on the ground says “The Train is Lorentz contracted and is shorter than the tunnel, so there IS a time when the train is fully within the tunnel.” To resolve the debate, the conductor puts rockets on the front and back end of the train such that both rockets fire simultaneously as the middle of the train passes through the middle of the tunnel.

Your task is now to explain what happens: Do the rockets hit the tunnel roof or go up into the sky? To answer this, draw a spacetime diagram of the events and use this describe the sequence of events from view points of both the train rest frame and the tunnel rest frame. Evaluate the veracity of the statements of the conductor and tunnel keeper above.

6. (a) A rocketship moving at a constant speed $v = \beta c$ in the positive x direction receives a light signal from a distant star in the $x - y$ plane. In the rest frame of the star, the light ray makes an angle θ with the velocity of the rocketship.

(a) Make a Lorentz transformation in the x -direction to find the angle θ' that the light ray makes with the $x' - axis$ in the rocketship's rest frame.

(b) Set $\theta' = \pi/2$ in your result of (a) and take limit as $\beta \rightarrow 1$. You should find that $\theta' < \pi/2$ corresponds to $\theta < \pi$. What does this imply about the stars an observer on the rocket ship would see if she had a hemispherical window to look out of in her direction of motion?