Physics 200 Problem Set 2

Hint: Draw pictures!

Problem 1

A school bus of (proper) length 10m is traveling at 0.6c. Lights at the front and back of the school bus flash simultaneously in the frame of reference of the school bus. In the frame of reference of the road, which light flashes first, and by how much?

Problem 2

The world's fastest hummingbird flies directly upwards ($\hat{y}$ direction) at 0.6c, starting from the ground. When the hummingbird reaches a height of 3km (in the frame of the ground), it is swallowed by an eagle. In the frame of a cheetah running at 0.8c in the $\hat{x}$ direction, at what time, height, and x' coordinate does the hummingbird get swallowed? Assume that both the fixed observer on the ground and the cheetah agree that the hummingbird left the ground at time zero and position zero. In the cheetah's frame, what were the $\hat{x}$ and $\hat{y}$ velocities of the hummingbird before it was swallowed?

Note: no actual hummingbirds were harmed in the creation of this question.

Problem 3

At $t = 0$ in the Earth's frame, astronomers spot a small asteroid 1 light year away (in the Earth's frame of reference) traveling directly towards the Earth at $4/5c$. To prevent certain doom for all humanity, they immediately launch a missile, which travels at 3/5 c towards the asteroid. Their plan is to have the missile explode just as it passes the asteroid. To achieve this, the missile is equipped with a timer, such that the missile will explode when the time runs out.

a) What should the timer on the missile be set to (you may wish to solve parts b and c first, though this is not necessary)?

b) If we call the direction towards the asteroid the $\hat{x}$ direction, and define the Earth to be at $x = 0$, what is the trajectory $x(t)$ of the asteroid in the frame of the Earth?

c) What is the trajectory $x'(t')$ of the asteroid in the frame of the missile? At what t' does the asteroid reach $x' = 0$? Does this agree with your answer for a (if you have already done it)?

d) What is the velocity of the missile in the asteroid's frame of reference?

Problem 4

Kermit's planet and Miss Piggy's planet are at rest relative to each other, 2 light years apart. At some time in the frame of the planets Kermit and Miss Piggy simultaneously leave their planets in rockets traveling at 0.5c heading for the other's planet. When the two rockets pass, Kermit and Miss Piggy each set their clocks to zero.

a) What does Kermit's clock read when he reaches Miss Piggy's planet?

b) What do observers in Kermit's frame observe Miss Piggy's clock to read when he reaches miss Piggy's planet?

c) What fraction of the way between Miss Piggy's planet and Kermit's planet does Kermit measure Miss Piggy to be when he arrives at Miss Piggy's planet?