Physics 200 Problem Set 4 Due at the end of class, Wed October 6th

1. Two events have coordinates (t_1, x_1) and (t_2, x_2) in the Earth's frame of reference.

(a) Write down the spacetime interval between these two events.

(b) Write down the coordinates of these two events as measured from a plane flying with velocity v in the negative x direction.

(c) Using your answer to part (b), compute and simplify the spacetime interval between the two events as observed from the plane. Does it agree with your answer to part (a)?

You have just (hopefully) proven that the spacetime interval is a Lorentz invariant quantity.

2. For each of the following pair of events, determine whether they have a spacelike, timelike or lightlike separation. For timelike separated events, compute the proper time between the two events and the velocity of an observer who sees them at the same location. For spacelike separated events, compute the proper distance between the two events and the velocity of an observer who sees them to be simultaneous.

(a) Event 1: x=-10m, t=0s; Event 2: x=20m, $t=10^{-6}s$

(b) Event 1: x=1 light-year, t=0; Event 2: x=2 light-years, t=0.5 year

(c) Event 1: x=0, t=1s; x=1 light second, t=2s.

3. Batman is driving down a straight road connecting two abandoned houses, separated by 20km. The Joker blows up the first house and then, 0.04ms later, the second house. It turns out that in Batman's frame of reference the two explosions happen at exactly the same time.

(a) How fast, and towards which house was Batman driving?

(b) If Batman saw the explosions at the same time, what was his position in the stationary frame when the first house blew up?

4. Hermione and Hagrid are out walking Hagrid's pet hippogriff one day when they spot

Harry Potter flying past on his broomstick at 0.3c. One second later, a large dragon flies past chasing Harry at 0.55c.

(a) If Hagrid observes Harry's broomstick to be 1m long, what would be the observed length of Harry's broomstick in the dragon's frame?

(b) If Harry's clock reads zero when he passes Hagrid and Hermione, what time does it read when the dragon catches him?

(c) Using graph paper, draw a spacetime diagram showing the trajectories of Hagrid, Harry, and the dragon in Hermione's frame of reference. Assume that Harry passes Hagrid and Hermione at x = t = 0, and make sure your graph shows the event where the dragon catches Harry.

(d) Imagine that Hermione casts a Stupefy spell to stun the dragon just as it reaches Harry. On your spacetime diagram from part c, indicate the event where Hermione casts the spell, assuming that the spell travels at the speed of light from Hermione's wand to the dragon.