## Physics 200 Problem Set 3

### Problem 1

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

a) event 1: $x = 10m$, $t = 6 \times 10^{-7}s$      event 2: $x = -50m$, $t = 4 \times 10^{-7}s$

b) event 1: $x = 10^8 m$, $t = 0$               event 2: $x = 7 \times 10^8 m$, $t = 4s$

c) event 1: $x = t = 0$                     event 2: $x = 2$ light years, $t = 1$ year

*Hint: it may be helpful to plot the pairs of events on a spacetime diagram.*

### Problem 2

Hermione and Hagrid are out walking Hagrid's pet hippogriff one day when they spot Harry Potter flying past on his broomstick at 0.5c. One second later, a large dragon flies past chasing Harry at 0.8c.

a) If Hagrid observes Harry's broomstick to be 2m 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.

### Problem 3

Hansel and Gretel both make a journey from Earth to the Gingerbread Planet, 1 light year away. Hansel travels at a constant speed of 0.3c there and back. Gretel leaves Earth at the same time, but travels at a constant acceleration (in the Earth's frame), and chooses this acceleration and her initial velocity so that she and Hansel reach the Gingerbread Planet simultaneously and arrive back at Earth simultaneously.

a) What is Gretel's acceleration and her initial velocity (no relativity required for this part). Hint: her acceleration is negative, and her velocity should be zero when she reaches the Gingerbread Planet

b) Sketch Hansel and Gretel's trajectories on a spacetime diagram

c) If Hansel and Gretel are the same age when they leave the Earth, who is older when they return, and by how much?