

# Physics 480/581

Problem Session No. 1

Monday, 27 August, 2018

1. Observer O watches a spacecraft moving at speed  $4/5$ , that left his observation point at time  $t = 0$ . One year later he wonders how long it has been for the people on the spacecraft. Please determine this number, and create a Minkowski diagram showing the two worldlines and the three events. Then, create a Minkowski diagram showing the same data, but as created by the observer on the spacecraft. On both diagrams, also show the planes of simultaneity of the people on the craft for their measurement of  $t' = 0$  and for  $t' = 1$ , as well as  $t = 0$  and  $t = 1$ .
2. Determine the equations relating the 4-vector displacement and the 4-vector velocity,  $u$ . Then show how this 4-velocity relates to the ordinary 3-vector velocity. Next determine the derivative w.r.t.  $\tau$  of  $u$ , calling this the 4-acceleration. Show how this is related to the ordinary 3-acceleration and the 3-velocity.
3. An observer at rest notes a passing inertial reference frame moving with velocity  $(\hat{x} + \hat{y} + \hat{z})/3$ . Work out the explicit Lorentz boost that relates measurements made in the two frames. The passing frame shoots missiles back toward the observer at rest, with velocity  $-\hat{x}/3$ . At what 3-velocity do these missiles pass the observer at rest? Use the Lorentz boost transf. to answer this last question.
4. Sarah leaves Richard on a spaceship moving at  $0.6c$  and travels to a star 10 light-years away. She stays there 5 years and then decides she misses Richard too much, and grabs a returning spaceship, also moving at  $0.6c$ , but headed back to Richard. Show these travels on Richard's Minkowski diagram. Sarah has been in three different reference frames, although the one on the star is the same as Richard's since he observes the star to be (approximately) at rest. Show all appropriate worldlines on a Minkowski diagram for each of her two other worldlines. How old are they both when she returns?