Physics 2301: Problem Set #8

These problems are due at the end of the day on Wednesday, March 18.

1. Morin 1.16 (Projectile with drag)

2. In a match of relativistic soccer, two attacking players (Beth in front and Becky behind) run at speed $v = 3/5$ relative to the ground, on which stands a stationary referee. When Becky is a distance L from the referee (as measured in the ground frame) she kicks the ball at speed $u = 4/5$ (relative to herself) toward Beth. The players have timed their running so that *they* deem the kicking event to be simultaneous with the event where Beth encounters the referee. Interesting events here are:

   - (0) Beth meets the referee
   - (1) Ball kicked
   - (2) Ball arrives at Beth
   - (3) Light from the kicking event (1) arrives at the referee

   (a) Agreeing to call (0) the "origin" event, find the spacetime coordinates x and t for events (1), (2) and (3) in both the ground frame and the Beth/Becky frame.

   (b) What is the spacetime interval between the events (2) and (3)? Check that you get the same answer in both frames.

   (c) Arrange these events in to two qualitatively accurate spacetime diagrams, one for each frame.

3. Morin 12.26 (Three photons) p. 616

4. Morin 12.28 (Another perpendicular photon) p. 616

5. Morin 12.31 (Equal angles) p. 617

6. Morin 13.9 (Same speed) p. 646

7. Morin 13.11 (Three particles) p. 646

8. Morin 14.14 (Both points of view) p. 663.

9. Given a spaceship which can provide a constant proper acceleration equal to $g = 9.8m/s^2$, how much proper time elapses on a trip to the galactic center, a distance of $L = 26000$ light years? Assume we accelerate for half the trip, then turn the rocket around and decelerate for the second half, so we are really asking you to find the proper time to go a distance $L/2$, then double it.

10. (BONUS) Morin 12.6 (Head-on collision). Use Mathematica to Solve the conservation laws and reproduce equation 12.87. Then obtain the same result by Lorentz transforming to the CM frame where the collision is as simple as flipping the sign of the momentum. That is, if Λ is the 2×2 matrix which transforms $\begin{pmatrix} E \\ p \end{pmatrix}$ from the lab to the CM frame, compute $\Lambda^{-1} \cdot \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \cdot \Lambda$.