Assignment III, PHYS 230 (Introduction to Modern Physics)
Fall 2015
Due 9/10/15 at start of class

As always, please put your answers on separate paper.

1. The proper length of one spaceship is three times that of another. The two spaceships are traveling in the same direction and, while both are passing overhead, an Earth observer measures the two spaceships to have the same length. If the slower spaceship is moving with a speed of $0.35c$, determine the speed of the faster spaceship.

2. When at rest, the Σ^- particle has a lifetime of 0.15 ns before it decays into a neutron and a pion. One Σ^- particle is observed to travel 3.0 cm in the lab before decaying. What was its speed. (Hint: Its speed was not $\frac{2}{3}c$).

3. As mentioned in class, the mean life-time of a μ^- particle in its rest-frame is 2.2 μs. Let's say some event creates a whole lot of μ^- particles that travel in a group. If these μ^- particles are all traveling at $0.9998c$ with respect to Earth, how far do they travel (as measured by someone on Earth) before 95% of the particles have decayed?

4. A stick of length $L_\circ$ is at rest in S, making an angle θ with the x-axis. Show that for an observer in the S' frame:

   a) the length is measured to be

   $$L' = L_\circ(\cos^2\theta/\gamma^2 + \sin^2\theta)^{1/2}$$

   b) the angle with respect to the x'-axis is measured to be

   $$\tan\theta' = \gamma\tan\theta$$

5. A Physics professor on Earth gives an exam to his students who are on a spaceship traveling at speed u relative to the Earth. The moment the ship passes the professor, he signals the start of the exam. If he wishes his students to have time $T_\circ$ (spaceship time) to complete the exam, show that he should wait a time (Earth time) of:

   $$T = T_\circ\sqrt{\frac{c-u}{c+u}}$$

   before sending a light signal telling them to stop. Hint: Remember that it takes some time for the second light signal to travel from the professor to the students.