Physics 124 – Problem Set # 1

(due Friday, October 4)

Throughout this course, homework problems from Griffiths' textbook will be from the Third Edition (with the brown and black cover). If you have the Second Edition (with the blue and black cover), check with a friend to be sure that you are doing the correct problems.

I assume that you have had some instruction in special relativity before coming to Physics 124, if only the brief introduction given at the end of Physics 121. In any case, it would be good to warm up this knowledge in preparation for 124, which will use relativity extensively. Here are some exercises to help you do this.

Let F be an inertial frame, and let F' be a frame moving to the right at a velocity v in the $\hat{z}$ direction with respect to F. Then position and time measurements in F are related to those in F' by

$$\begin{aligned} ct &= \gamma(ct' + \beta z') \\ z &= \gamma(z' + \beta ct') \\ x &= x' \\ y &= y' \end{aligned} \tag{1}$$

where $\beta = v/c$, $\gamma = 1/\sqrt{1 - v^2/c^2}$, and c is the speed of light. The relation giving F' quantities in terms of F quantities is the same, with $v \to -v$. Use this transformation—the Lorentz transformation—to do the following exercises:

1. Write the F' quantities in terms of F measurements, and then plug in the formulae above giving F measurements in terms of F'. Show that what results is the identity.

2. Show that a clock at rest with respect to F', at $z' = 0$, runs slow with respect to F.

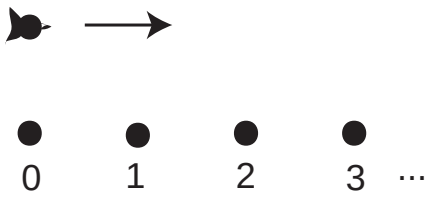
3. Consider a wooden barn of length ℓ with two doors. A steel bar of length 2ℓ is travelling at the speed $\sqrt{3}/2\, c$ with respect to F. Thus, by the Lorentz contraction, the bar fits exactly into the barn at a certain time, say, $t = 0$. Two students in F can close the barn doors at $t = 0$ and have the bar trapped. Taking the time and position of the closing of the back door to be $t' = 0, z' = 0$ in F', find the time and position in F' at which the front door is closed. Why would an observer in F' claim that the two students cheated? What happens to the barn and the bar at $t > 0$?

4. Griffiths, problem 12.8.

5. Griffiths, problem 12.13.

6. Griffiths, problem 12.16.

7. The emperor of Ratner's Star is reviewing his legions. He has instructed his ships to line up with a spacing of 1 light-second (3×10^8 m), as shown. He will fly past them, 1 light-second away from the formation, at a speed of $0.8c$. He has instructed all of the spaceship commanders to fire a salute (which must be a light-signal, since there is no sound in space) at the moment–in their frame of reference–that he passes the first ship of the formation.



   (a) Find, algebraically, the time, in the emperor's frame of reference, at which he receives the signal from the ships 0 and 1. You might wish to do this calculation, first, directly in the emperor's frame and, second, by working in the fleet's frame and then transforming.

   (b) Find the general formula for the time that the emperor receives the signal from the nth ship.

   (c) Compute numerically the time at which the emperor receives the signal from each of the first four ships. In what order does he receive the signals?