PHYS 2604
Assignment #3

Given: Thursday, October 1, 2009
Due: Thursday, October 8, 2009 **in class**

1. An unstable subatomic particle with a mean proper lifetime of 3.0 μs is formed in a collision in a high energy accelerator and moves through the detector (lab frame) with a speed of 0.8 c, where c is the speed of light.

   a) What is the mean lifetime of the particle in the lab frame?

   b) How far does the particle travel, on average, from the point of its creation **in the laboratory** to its decay?

   c) What is the distance in part (b), as observed from the reference frame in which the particle is at rest? (that is, the distance the particle sees the detector move)

2. An observer A is on a rocket ship that passes the earth at a speed of $1.8 \times 10^8\ m/s$. An observer B on earth sets her watch so that it reads $t = 0$, the same as A's watch, just as the ship passes the earth.

   a) If observer B looks at A's watch through a telescope, what time does B see on A's watch when B's watch reads 30 s?

   b) If A observes B's watch, what time does she see when her watch reads 30 s?

   Note that the transit time of the light signal must be taken into account.

3. Consider a source of light that is moving parallel to the x-axis with a speed v relative to the unprimed frame S. The light source defines the primed frame S'.

   a) A beam of light from the source is emitted in the $x' - y'$ plane at an angle θ' with respect to the x'- axis. Transform the velocity components of the beam, $u'_x = c\ \cos\theta'$ and $u'_y = c\ \sin\theta'$, to the unprimed frame and find the resultant of the transformed components (namely, the magnitude of the velocity of the beam in the unprimed frame).

   b) Show that the angle θ made by the beam with the x-axis is given by

   $$\cos\theta = \frac{\cos\theta\prime + (v/c)}{1 + (v/c)\cos\theta\prime}.$$

   c) The axis of a cone of light in the primed frame is parallel to the x-axis. Given that the half-angle of the cone is 60° and that $v = 0.8c$, find the half-angle of

the cone in the unprimed frame. Why would the result in this problem be called the "headlight effect"?

4. This is problem 18 in Chapter 2 of Thornton and Rex. It assumes the result of time dilation.

Show that the experiment depicted in Figure 2.11 (reproduced below) and discussed in the text leads to the derivation of the length contraction.

A meterstick lies along the x'-axis in the moving system, denoted as K' (Fig 2.11a). The two systems K and K' are aligned at $t = t' = 0$. A mirror is placed at the end of the meterstick, and a flashbulb goes off at the origin at $t = t' = 0$, sending a light pulse down the axis, which is reflected at the end of the stick and returned.

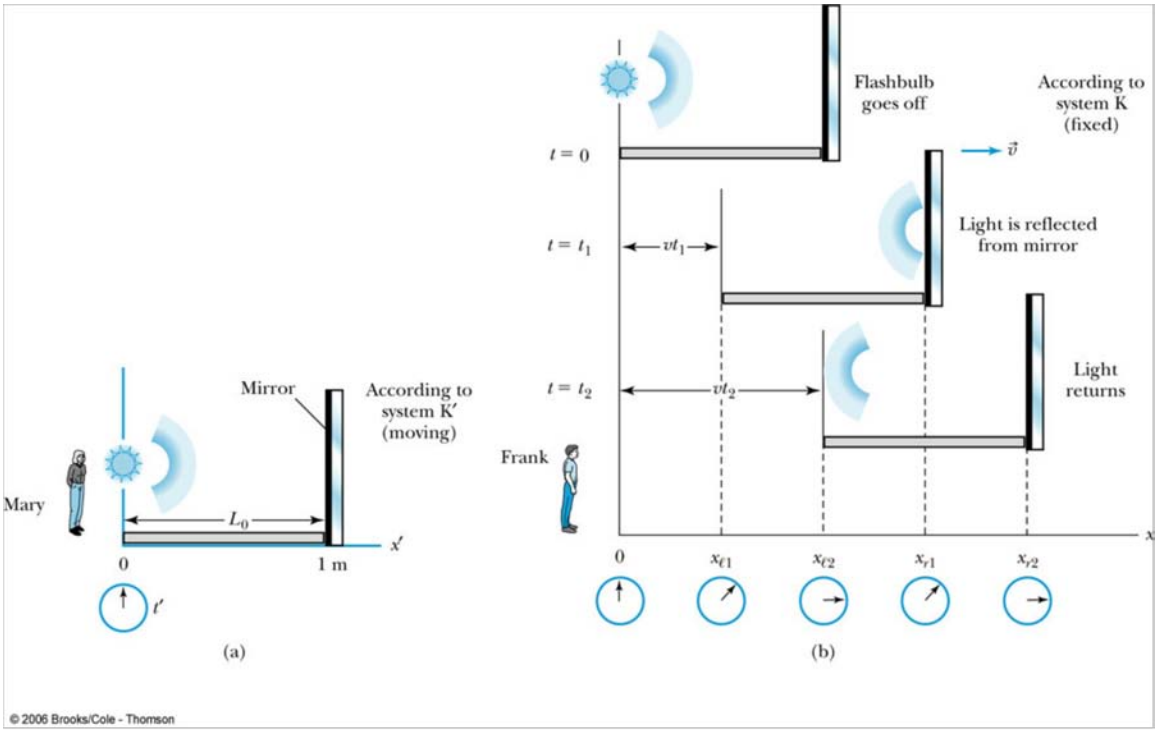

Fig 2.11, pg 37