Assignment II, PHYS 230 (Introduction to Modern Physics)
Spring 2017
Due 1/25/17 at start of class

As promised on the first day of class, I am only planning to assign work based on material we have already lectured on. However, you are getting this assignment on the third day of class – when day one was devoted largely to describing the big-picture of the course and days two/three were largely devoted to establishing the big-picture framework about Special Relativity.

The facts above result in 2 impacts for you. (1) HW 2 gets to be a fairly straightforward assignment. Most of your homework assignments will probably be more lengthy than this. I only bring this up so that you don't use the difficulty/time commitment needed to complete this assignment as a yard-stick to estimate the time/effort needed on future homeworks. This homework assignment is easier than most. (2) The first couple of questions on this assignment rely on some external reading/video watching. In order to get through as much content as possible, I am not going to talk about the Michelson-Morley experiment in lecture. However, you are free to ask me any questions you have about it if you are interested.

To keep up with lecture, you should also read Chapters 1 and 2 of Taylor (your course text) as soon as possible (preferably before we get to that content in lecture).

1. Read the summary of the Michelson-Morley Experiment at http://larsenml.people.cofc.edu/MichelsonMorley.pdf and watch the video at http://tinyurl.com/micmorvideo. Based on these sources, answer the following questions.

   a) Based on an equation in the first link, if you used $\epsilon_\circ = 8.854 \times 10^{-12}$ C^2/(N m^2) and $\mu_\circ = 4\pi \times 10^{-7}$ N s^2/C^2, what value would you get for c? (You may use a calculator; make sure to keep at least 4 sig figs).

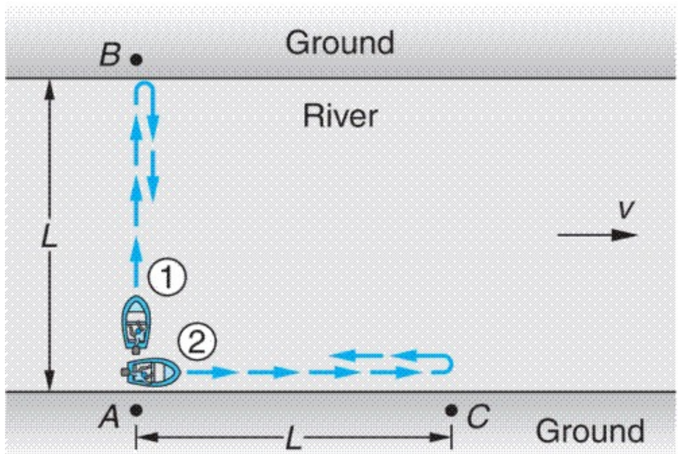
   b) If we treated "empty" space as a solid with a density associated with 1 hydrogen atom per cubic centimeter and we (erroneously) assumed that the aether exists, what would you expect the bulk modulus of space to be to get a speed of light moving at 3.00×10^8 m/s? (Make sure to include correct units; you may use a calculator. You might need to know that 6.02×10^{23} atoms of Hydrogen has a mass of about 1.0079 grams.

2. See the figure below. v (the velocity of the water) is steady at 5 m/s, each boat always travels with a speed (relative to the water) of 13 m/s and L is 3.5 km.

   a) How long does it take boat 1 to return to point A?

   b) How long does it take boat 2 to return to point A?

   c) Which boat is faster, and by how much?



3. In class, we either have derived (or are in the process of deriving) the Lorentz Transformation. The final result of this transformation reads:

$$
\begin{aligned}
x' &= \gamma(x - vt) \\
y' &= y \\
z' &= z \\
t' &= \gamma(t - vx/c^2)
\end{aligned}
$$

With $\gamma \equiv \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$. For this problem, let v (the relative velocity between the primed and the unprimed frame) be equal to $3c/5$.

   a) What is the value of γ for this relative speed between the frames?

   b) If an event (E1) occurs at the coordinates $x = 3.1$ m, $y = 2.3$ m, $z = -3.4$ m, and $t = 10$ ns, what are the coordinates of the event E1 in the primed frame?

   c) If a different event (E2) occurs at coordinates $x = -2.1$ m, $y = -7.1$ m $z = 0$ m, and $t = 7.5$ ns, what are the coordinates of event E2 in the primed frame? [You should notice that in the primed frame, event 2 occurs after event 1, even though in the unprimed frame event 1 occurs after event 2!]

   d) If an event (E3) occurs at the origin of the primed frame at $t' = 10$ s, at what coordinates did the event occur in the unprimed frame?