University of Alabama
Department of Physics and Astronomy

PH 102 / LeClair Summer II 2012

Problem Set 1: Relativity

Instructions:

1. Answer all questions below. Show your work for full credit.
2. All problems are due Monday 9 July 2012 by the end of the lab period.
3. You may collaborate, but everyone must turn in their own work.

1. A classic "paradox" involving length contraction and the relativity of simultaneity is as follows: Suppose a runner moving at $0.75c$ carries a horizontal pole 15 m long toward a barn that is 10 m long. The barn has front and rear doors. An observer on the ground can instantly and simultaneously open and close the two doors by remote control. When the runner and the pole are inside the barn, the ground observer closes and then opens both doors so that the runner and pole are momentarily captured inside the barn and then proceed to exit the barn from the back door. Do both the runner and the ground observer agree that the runner makes it safely through the barn? Justify your answer. *We will go over this in class on Monday.*

2. An astronaut takes a trip to Sirius, which is located a distance of 8 lightyears from the Earth. The astronaut measures the time of the one-way journey to be 6 yr. If the spaceship moves at a constant speed of $0.8c$, how can the 8-ly distance be reconciled with the 6-yr trip time measured by the astronaut?

3. A proton is accelerated to a velocity $v = 0.999c$ and sent down an evacuated metal tube 100 m long. Take the speed of light as $c = 3.0 \times 10^8$ m/s.

(a) In the protons reference frame, how long is the tube? **(b)** In the protons frame, how long does it take to traverse the length of the tube? **(c)** In the laboratory frame, how long does it take for the proton to traverse the length of the tube?

4. An atomic clock aboard a spaceship runs slow compared to an Earth-based atomic clock at a rate of 2.0 seconds per day. What is the speed of the spaceship?