UNIVERSITY OF ALABAMA
Department of Physics and Astronomy

PH 102 / LeClair Summer II 2009

Problem Set 1: Relativity

Instructions:

1. Answer all questions below. Show your work for full credit.
2. Due before the end of the day, 9 July 2009
3. Email submission: leclair.homework@gmail.com
4. Hard copies: Gallalee 110 or Bevill 228.
5. You may collaborate, but everyone must turn in their own work

1. The orbital speed of the Earth around the Sun is 30 km/s. In one year, how many seconds do the clocks on the Earth lose with respect to the clocks of an inertial reference frame at rest relative to the Sun? *Hint: if v/c is small, the following approximation is valid:*

$$\sqrt{1-\frac{v^2}{c^2}} \approx 1 - \frac{1}{2}\frac{v^2}{c^2}$$

2. A cannonball flies through our classroom at a speed of $0.30c$. Measurement of the transverse diameter ("width") of the cannonball gives a result of 0.20 m. What can you predict for the measurement of the longitudinal diameter ("length") of the cannonball?

3. A flexible drive belt runs over two flywheels whose axles are mounted on a rigid base (Fig. 1). In the reference frame of the base, the horizontal portions of the belt have a speed v and therefore are subject to length contraction, which tightens the belt around the flywheels. However, in a reference frame moving to the right with the upper portion of the belt, the *base* is subject to length contraction, which ought to loosen the belt around the flywheels. Resolve this "paradox" with by a qualitative argument. *Hint: consider the lower portion of the belt as seen in the reference frame of the upper portion.*

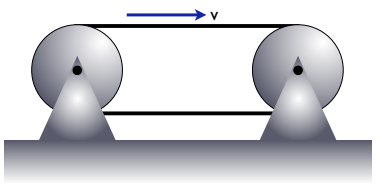

Figure 1: *Question 3*

4. A spaceship is moving at a speed of $0.60c$ toward the Earth. A second spaceship, following the first one, is moving at a speed of $0.90c$ toward the Earth. What is the speed of the second spaceship as observed in the reference frame of the first?

5. Consider a particle of mass m moving at a speed of $0.10c$. What is its kinetic energy according to the relativistic formula? What is its kinetic energy according to the Newtonian formula? What is the percent deviation between these two results?

6. Show that the momentum of a particle can be expressed in the concise form $\vec{\mathbf{p}} = \frac{E}{c^2}\vec{\mathbf{v}}$.