PH 102-2 / LeClair   Spring 2008

Problem Set 1: Special Relativity

Instructions:

1. Answer all questions below. Show your work for full credit.

2. Due before 5pm, 18 Jan 2008

3. Problem sets may turned in *via* email or hard copy

4. Hard copies may be left in Dr. LeClair's mailbox (Gallalee 206) or office (Bevill 228)

5. You may collaborate, but everyone must turn in their own work

1. 5 points. How fast must a meter stick be moving if its length is measured to be only $0.50\,\text{m}$?

2. 5 points. For what velocity does $\gamma = 1.05$? For speeds lower than this, time dilation and length contraction are effects are less than 5%.

3. 10 points. The period of a pendulum is measured to be $2.00\,\text{s}$ in the reference frame of the pendulum. What is the period when measured by an observer moving at a constant speed of $0.900c$ relative to the pendulum?

4. 10 points. At what speed is a clock moving if it is measured to run at half the rate as a clock at rest with respect to an observer?

5. 10 points. A spaceship is measured to be $75.0\,\text{m}$ long and $25.0\,\text{m}$ wide while at rest. Another observer views the spaceship as it flies by at $0.95c$. What length and width does this observer measure?

6. 15 points. Two spacecraft are moving in opposite directions. An observer on earth measures the speed of the first to be $0.80c$, and the speed of the second to be $0.9c$. What is the velocity of the second craft as observed by passengers of the first?

7. 10 points. A car speeds past an observer on the ground at $0.9c$. A passenger in the car throws a ball out the car window at $0.7c$ relative to the car. What is the velocity of the ball with respect to the observer on the ground?

8. 20 points. A muon formed high in the Earth's atmosphere travels at $v = 0.990c$ for $4.60\,\text{km}$ before it decays into an electron, a neutrino, and an antineutrino ($\mu^- \rightarrow e^- + \nu + \bar{\nu}$). **(a)** How long does the muon live, as measured in its own reference frame? **(b)** How far does the Earth travel, as measured in the frame of the muon?

9. 15 points. The nonrelativistic expression for the momentum of a particle $p = mv$ agrees with experiments when $v \ll c$. For what speed does the nonrelativistic equation give an error of **(a)** 1.0%? **(b)** 5.0%?