# Homework Assignment #6 — Physics 17 Fall 99

Due: Monday, November 29

1. Show that Maxwell's equations written in terms of the vector and scalar potentials are invariant under Lorentz transformations. Assume that (A_x, A_y, A_z, ϕ) and (J_x, J_y, J_z, ρ) are four-vectors, i.e, that they transform under Lorentz transformations in a similar way to (x, y, z, t). I will show you in class that this is indeed the case.

2. A rocketship of proper length l_0 travels at constant velocity v relative to a frame S. The nose of the ship passes the origin of S at $t = t' = 0$, and at this instant a light signal is sent from the nose to the tail of the ship.

   (a) When, by the rocketship time (t'), does the signal reach the tail?

   (b) At what time, as measured in S, does the signal reach the tail?

   (c) At what time, as measured in S, does the tail of the ship pass the origin of S?

3. At noon a rocketship passes the earth with a velocity $0.8c$. Observers on the ship and on earth agree that it is noon.

   (a) At 12:30 P.M. as read by the rocket clock, the ship passes a space station that is stationary with respect to earth and whose clocks read earth time. What time is it at the station?

   (b) How far from earth (in earth coordinates) is the station?

   (c) At 12:30 P.M. rocketship time the ship reports by radio back to earth. When (by earth time) does the earth receive the signal?

   (d) The earth replies immediately. When (by rocket time) is the reply received?

4. A rod of proper length l_0 is at rest in a frame S'. It lies in the (x', y') plane and it makes an angle of $\arcsin(3/5)$ with the x' axis. If S' moves with velocity v parallel to the x axis of another frame S:

   (a) What must be the value of v if, as measured in S, the rod is at $45°$ to the x axis?

   (b) What is the length of the rod as measured in S under these conditions?

5. A rod of proper length l_0 points along the x axis but moves in a direction making an angle of $45°$ to this axis (see figure). A platform, also parallel to the x axis, lies in the rod's way, but a slit of proper length $1.1l_0$ has been

cut out of it. What happens the speed of the rod is $v = 0.9c$? Does the rod go through the slit? Analyze the problem in the reference frames of the rod and the platform.
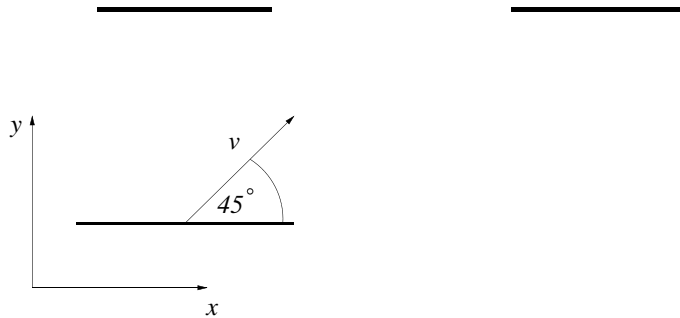
6. Consider three galaxies A,B and C. An observer in A measures the velocities of C and B and finds that they are moving in opposite directions each with velocity $0.7c$ relative to him. Thus according to measurements in his frame, the distance between them is increasing at the rate $1.4c$. What is the speed of A observed in B? What is the speed of C observed in B?