Zhejiang University

Department of Physics

General Physics (H)   Problem Set #9

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1. In 1962, when Mercury astronaut Scott Carpenter orbited the Earth 22 times, the press stated that for each orbit he aged 2 millionths of a second less than he would have had he remained on Earth. (a) Assuming that he was 160 km above the Earth in a circular orbit, determine the time difference between someone on Earth and the orbiting astronaut for the 22 orbits. (b) Did the press report accurate information? Explain.

2. A rod of length L_0 moving with a speed v along the horizontal direction makes an angle θ_0 with respect to the x' axis. (a) Show that the length of the rod as measured by a stationary observer is

$$L = L_0\left[1 - (v/c)^2\cos^2\theta_0\right]^{1/2}$$

(b) Show that the angle that the rod makes with the x axis is given by

$$\tan\theta = \gamma\tan\theta_0.$$

These results show that the rod is both contracted and rotated. (Take the lower end of the rod to be at the origin of the primed coordinate system.)

3. A square with side L flies past you at a speed v, in a direction parallel to two of its sides. You stand in the plane of the square. When you see the square at its nearest point to you, show that it *looks* to you like it is rotated, instead of contracted. (Assume that L is small compared with the distance between you and the square.)

4. Two planets, A and B, are at rest with respect to each other, a distance L

apart, with synchronized clocks. A space ship flies at speed v past planet A toward planet B and synchronizes its clock with A's right with it passes A (assume their clocks both read zero). The spaceship eventually flies past planet B and compares its clock with B's. We know that, from working in the planets' frame, when the spaceship reaches B, B's clock reads L/v. And the spaceship's clock reads sL/v, because it runs slow by a factor of $1/s$ when viewed in the planets' frame. How would someone on the spaceship quantitatively explain to you why B's clock reads L/v (which is more than its own sL/v), considering that the spaceship sees B's clock running slow?

5. A train with proper length L moves at speed $c/2$ with respect to the ground. A ball is thrown from the back to the front, at speed $c/3$ with respect to the train. How much time does this take, and what distance does the ball cover, in:

   (a) The train frame?

   (b) The ground frame? Solve this by

      i. Using a velocity-addition argument.

      ii. Using the Lorentz transformations to go from the train frame to the ground frame.

   (c) The ball frame?

   (d) Verify that the invariant interval is indeed the same in all three frames.

   (e) Shown that the times in the ball frame and ground frame are related by the relevant γ factor (or s factor).

   (f) Ditto for the ball frame and the train frame.

   (g) Show that the times in the train frame and ground frame are not related by the relevant γ factor. Why not?