Phsx 2220 - Homework #11

38-1. Find the speed of a particle that takes 2.0 y longer than light to travel a distance of 6.0 ly.

38-2. The mean lifetime of stationary muons is measured to be 2.2 μs. The mean of high-speed muons in a burst of cosmic rays observed from Earth is measured to be 16 μs. Find the speed of these cosmic-ray muons relative to Earth.

38-3. You wish to make a round trip from Earth in a spaceship, traveling at constant speed in a straight line for 6 months and then returning at the same constant speed. Your wish further, on your return, to find Earth as it will be a thousand years in the future. How fast must you travel?

38-4. A meter stick in frame S′ makes an angle of 30° with the x′ axis. If that frame moves parallel to the x axis with speed 0.90 c relative to frame S, what is the length of the stick as measured from S?

38-5. A space traveler takes off from Earth and moves at speed 0.99 c toward the star Vega, which is 26 ly distant. How much time will have elapsed by Earth clocks (a) when the traveler reaches Vega and (b) when Earth observers receive word from the traveler that she has arrived? (c) How much older will Earth observers calculate the traveler to be (according to her) when she reaches Vega than she was when she started the trip?

38-6. Observer S assigns the spacetime coordinates x = 100 km and t = 200 μs to an event. What are the coordinates of this event in frame S′, which moves in the direction of increasing x with speed 0.950 c relative to S? Assume x = x′ = 0 at t = t′ = 0.

38-7. An experimenter arranges to trigger two flashbulbs simultaneously, producing a big flash located at the origin of his reference frame and a small flash at xs = 30.0 km. An observer, moving at a speed of 0.250 c in the direction of increasing x, also views the flashes. (a) What time interval between them does she find? (b) Which flash does she say occurs first?

38-8. Frame S′ moves relative to frame S at 0.62 c in the direction of increasing x. In frame S′ a particle is measured to have a velocity of 0.47 c in the direction of increasing x′. (a) What is the velocity of the particle with respect to frame S? (b) What would be the velocity of the particle with respect to S if the particle moved (at 0.47 c) in the direction of decreasing x′ in the S′ frame? In each case, compare your answers with the prediction of the classical velocity transformation equation.

38-9. It is concluded from measurements of the red shift of the emitted light that quasar Q_1 is moving away from us at a speed of 0.800 c. Quasar Q_2, which lies in the same direction in space but is closer to us, is moving away from us at a speed of 0.400 c. What velocity for Q_2 would be measured by an observer in Q_1?

38-10. Some of the familiar hydrogen lines appear in the spectrum of quasar 3C9, but they are shifted so far toward the red that their wavelengths are observed to be three times longer than those observed for hydrogen atoms that are stationary in a laboratory. (a) Show that the classical Doppler equation gives a relative velocity of recession greater than c for this situation. (b) Assuming that the relative motion of 3C9 and Earth is due entirely to recession, find the recession speed that is predicted by the relativistic Doppler equation.

38-11. A particle has a speed of 0.990 c in a laboratory reference frame. What are its kinetic energy, its total energy, and its momentum if the particle is (a) a proton and (b) an electron? A proton's rest energy is m_pc^2 = 938 MeV and an electron's rest energy is m_ec^2 = 0.511 MeV.

38-12. A 5.00 grain aspirin tablet has a mass of 320 mg. For how many miles would the energy equivalent of this mass power an automobile? Assume 30.0 mi/gal and a heat of combustion of 1.30×10^8 J/gal for the gasoline used in the automobile.