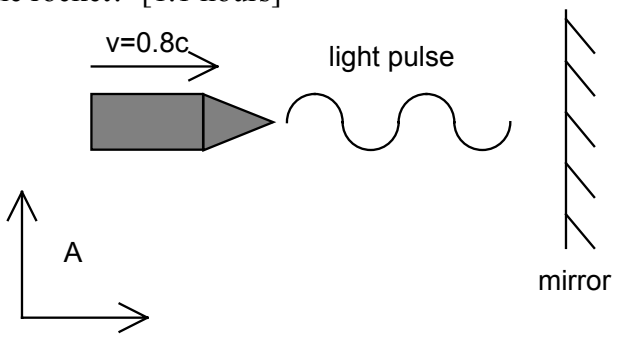
PHY 140Y – FOUNDATIONS OF PHYSICS
2001-2002
Tutorial Questions #12
December 3/4

Note: Answers are given in brackets. Try getting full solutions before the tutorials!

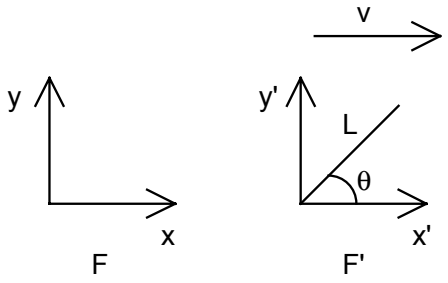
Lorentz Velocity Addition, Time Dilation, and Lorentz Contraction

1. Two spaceships are travelling with velocities of 0.6c and 0.9c relative to a third observer.
(a) What is the speed of one spaceship relative to the other spaceship if they are going in the same direction? [2.0×10^8 m/s]
(b) What is their relative speed if they are going in opposite directions? [-2.9×10^8 m/s]

2. A rocket moves towards a mirror at 0.8c relative to the reference frame A, shown below. The mirror is stationary relative to A. A light pulse emitted by the rocket travels to the mirror and is reflected back to the rocket. The front of the rocket is 1.8×10^{12} m from the mirror (as measured in A) at the moment that the light pulse leaves the rocket. What is the total travel time of the pulse as measured by an observer in
(a) reference frame A, and [1.8(5) hours]
(b) the front of the rocket? [1.1 hours]



3. A rod of proper length L is at rest in reference frame F'. The rod lies in the (x', y') plane and makes an angle of θ with the x' axis. F' moves with a constant velocity v parallel to the x-axis of another frame F.
(a) What is the value of v if, as measured in F, the rod is at 45° to the x axis? [1.98×10^8 m/s]
(b) What is the length of the rod as measured in F under the situation given in part (a)? Derive general expressions, and also look at the special case of $\theta = \sin^{-1}(3/5)$. [$L2^{0.5}\sin\theta$]



Lorentz Transformations

4. Spaceship A of proper length L is travelling east at speed v_A, and spaceship B of proper length 2L is travelling west at speed v_B, both as seen from Earth. The pilot of spaceship A sets a clock to zero when the front of spaceship B passes by. (The spaceship pilots sit in the nose cones.) Use Lorentz transformations to derive an expression for the time at which, according to the pilot of spaceship A, the tail of spaceship B passes by. [$2L/\gamma|u|$]

Energy in STR

5. Solar energy reaches the Earth at the rate of about 1400 W/m^2 of surface area perpendicular to the direction to the Sun. By how much does the mass of the Sun decrease in each second? The mean radius of Earth's orbit is 1.5×10^8 km. Would the real mass loss of the Sun be greater than or less than your calculated answer, and why? [4.4 billion kg/second]

6. A proton (mass = 1.67×10^{-27} kg) is moving at speed v = 0.900c.
   (a) What is the proton's total relativistic energy? [3.44×10^{-10} J]
   (b) What is the proton's kinetic energy? [1.94×10^{-10} J]
   (c) What is the proton's rest energy? [1.50×10^{-10} J]
   (d) What is the magnitude of the proton's relativistic momentum? [1.03×10^{-18} kg m/s]