Tutorial 4

Special theory of relativity

1. Find the speed of a relativistic particle whose mass is 40% larger than its rest mass.
2. What should the speed of an electron ($m_e = 9\times10^{-31}\text{kg}$) be, so that its mass is equal to the rest mass of a proton ($m_p = 1.67\times10^{-27}\text{kg}$) ?
3. What is the length of a meter stick which is moving parallelly to its length at a speed which is 0.6c?
4. Knowing that the mass of a meter stick is twice its rest mass, find its corresponding length when the meter stick moves in a direction which a) is parallel to its length; b) makes an angle $\theta = 30^\circ$ with its length.
5. 5. A beam of π^+ mesons (proper lifetime $2.5\times10^{-8}\text{s}$) moving at 0.6c is produced in the laboratory. Calculate the distance traveled by the particle beam before it is reduced to $1/e^2$ of its initial value.
6. In the S frame of reference (SFR) an event B occurs $2\,\mu\text{sec}$ later than an event A at a point located 3km away from the point where event A occurs. At what speed should an observer move along the positive x direction of SFR so that he can report that the two events occurred simultaneously with respect to his proper frame of reference (S'FR)?
7. An observer (SFR) sees an explosion at $x_1 = 400\text{ m}$ along the x direction of his frame of reference, SFR. $4\,\mu\text{sec}$ later, a second explosion is observed at $x_2 = 1000\text{ m}$. The observers of the S'FR , which is moving at the relativistic speed v, notice that the two explosions took place at the same position along the positive Ox' direction. Find the time interval between explosions as measured by the observers of S'FR and the speed v of the S' frame of reference.
8. The breakfast time of an astronaut is 10 minutes (measured by his own watch). Compute the breakfast time measured by the observers on Earth, knowing that the spaceship is moving at a speed which is 0.6*c*. What distance will the spaceship travel while the astronaut is having his breakfast?
9. Compute the momentum and the speed of an electron whose kinetic energy is 3 times larger than its rest energy.
10. Compute the total energy, the kinetic energy and the momentum of a proton moving at 0.6c. The rest energy of a proton is $E_0 = 938.28\text{MeV}$.
11. What quantity of energy is necessary to accelerate a particle whose rest mass is m_0 from rest to a speed which is 0.5c? Express the result in multiples of the rest energy E_0 .
12. A particle whose speed is 0.6c with respect to the Ox direction of the laboratory frame of reference undergoes a plastic collision with another particle which gets closer in the same direction, at a speed 0.8c. After the collision, the resulted particle stays at rest. Find the ratio of the rest masses of the two particles.