Additional practice problems (Relativity)

1. A rod moves lengthwise with a constant velocity *v* relative to the inertial reference frame S. At what value of *v* will the length of the rod in this frame be 0.5% shorter than its proper length? (Answer 0.1c)
2. A rod flies with constant velocity past a mark which is stationary in the reference frame S. In the frame S it takes 20 ns for the rod to fly past the mark. In the reference frame fixed to the rod the mark moves past the rod for 25 ns. Find the proper length of the rod. (Answer 4.5 m)
3. The proper lifetime of an unstable particle is 10 ns. Find the distance this particle will travel until its decay in the laboratory frame of reference where its lifetime is equal to 20 ns. (Answer 5 m)
4. What work has to be performed to increase the velocity of a particle of rest mass $m_0$ from 0.6c to 0.8c? Compare the result with the value calculated from the classical formula. (Answer 0.42 $m_0c^2$ instead of $0.14m_0c^2$).
5. Find how the momentum of a particle of rest mass $m_0$ depends on its kinetic energy. Calculate the momentum of a proton whose kinetic energy equals 500 MeV. (Answer 1.09 GeV/c)
6. *A neutron with kinetic energy $E_k= 2m_0c^2$ , where $m_0$ is its rest mass, strikes another, stationary, neutron. Find a) the combined kinetic energy of both neutrons in the reference frame of their center of inertia; b) the velocity of the center of inertia of the system. Hint: make use of the invariant $E^2-p^2c^2$ remaining constant on transition from one inertial reference frame to another (E is the total energy of the system, p is its composite momentum.) (Answer 777 MeV, $2.12x10^8$ m/s)
7. A particle of rest mass $m_0$ with kinetic energy $E_k$ strikes a stationary particle of the same rest mass. Find the rest mass and the velocity of the compound particle formed as a result of the collision. (Answer $sqrt[2m_0(E_k+2m_0c^2)]/c$, $c*sqrt[E_k/(E_k+2m_0c^2)]$ )
8. The spectrum of light from a distant star contains a yellow sodium line (290 nm) that is shifted from its standard (on Earth) position by 20 nm towards longer wavelengths. What is the speed of the star relative to the Earth?