Dr. Sasha

Please, solve this problem and also show the steps to solve it.

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1) A rod of length L_0 moves with speed v along the horizontal direction. The rod makes an angle α_0 with respect to the x' axis (the S' frame to be the rest frame of the rod).

a) Determine the length of the rod as measured by a stationary observer.

b) Determine the angle α the rod makes with the x axis.?

2) A stationary observer on Earth observes spaceships A and B moving in the same direction toward the Earth. Spaceship A has speed 0.5 c and spaceship B has speed 0.8 c. Determine the velocity of spaceship A as measured by an observer at rest in spaceship B.

3) Consider a light beam passing through a horizontal column of water moving with velocity v.

a) Determine the speed u of the light measured in the lab frame when the beam travels in the same direction as the flow of the water.

b) Determine an approximation to this expression valid when v is small.

4) Show that the energy-momentum relationship $E^2 = p^2c^2 + m^2c^4$ follows from $E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}$ and $p = \frac{m \cdot v}{\sqrt{1-\frac{v^2}{c^2}}}$.

5) The free neutron is known to decay into a proton, an electron and an antineutrino (of zero rest mass) according to

$$n \rightarrow p + e^- + \bar{\nu}_e$$

This is called beta decay. The decay products are measured to have a total kinetic energy of (0.781 ± 0.005) MeV. Show that this observation is consistent with the Einstein mass-energy relationship ($E = mc^2$).

6) An electron e^- with kinetic energy 1000 MeV makes a head-on collision with a positron e^+ at rest. (A positron is an antimatter particle that has the same mass as the electron but opposite charge.) In the collision, the two particles annihilate each other and are replaced by two photons of equal energy, each traveling at angles α with the electron's direction of motion. (A photon is a massless particle of electromagnetic radiation having energy E = pc.) The reaction is

$$e^- + e^+ \rightarrow 2\gamma\,.$$

Determine the energy E , momentum p and angle of emission α of each photon.