

TEST 1. PHYS 321. October 2, 2007

From 2:00 to 3:15pm. Room MR 418

NAME:

You are allowed to have a sheet with equations.

1.1 Concepts

Two observers are moving relative to each other. Which of the following quantities will they always measure to have the same value: (a) their relative velocity, (b) the time between two events, (c) the length of an object (d) the speed of light in vacuum, (e) the speed of a third observer. Justify your answer in each case.

1.2 Concepts

Why do you think the development of Newtonian mechanics preceded the more refined relativistic mechanics by so many years?

1.3 Concepts

What do you think would be different in every day life if the speed of light were 10 m/s instead of its actual value?

1.4 Concepts

Starting from the definition of energy in relativity

$$E = \gamma mc^2, \tag{1}$$

show that in the Newtonian limit the energy approaches the Newtonian kinetic energy plus the rest mass energy.

1.5 Concepts

At what speed is the momentum of a particle twice as great as the result obtained from the non-relativistic expression?

1.6 Concepts

In positron annihilation an electron and a positron collide and disappear, producing electromagnetic radiation. If each particle has a mass of 9.11×10^{-31} kg and they are at rest just before the annihilation, find the total energy of the radiation (in Joules and eV).

1.7 Concepts

(a) What is the speed, $\beta = v/c$, of an electron ($m_e = 0.511MeV/c^2$) with a momentum of 10 MeV/c? (b) What is the speed, $\beta = v/c$, of a proton ($m_p = 940MeV/c^2$) with a momentum of 10 MeV/c?

2. A rod whose length at rest is 10 meters is moving to the right along the positive x-axis of the S-frame with velocity $V = 0.8c$. An observer riding on the rod (i.e. in the S'-frame) sets off two explosions simultaneously, so he says. If the rod is parallel to the x-axis how far apart are the two explosions (in meters) in the S-frame? Is this length the same as the length of the rod as measured in the S-frame? If your answer is no, then what is the length of the rod (in meters) as measured in the S-frame?

3. A particle of unknown mass M decays into two particles of known masses $m_1 = 0.5 \text{ GeV}/c^2$ and $m_2 = 1 \text{ GeV}/c^2$, whose momenta are $\vec{p}_1 = 2\text{GeV}/c \hat{y}$ (in the y-direction) and $\vec{p}_2 = 1.5\text{GeV}/c \hat{x}$ (in the x-direction). Find the mass M and its speed.

4. A neutral pion travels along the x direction and decays into two photons, one ejected in the positive x direction and the other in the $-x$ direction. The first photon has 3 times the energy of the second. Prove that the original pion speed is $c/2$.