Chapter 37 Tutorial

Modern Physics - VI

Relativity

Question 1:
The positive muon (μ^+), an unstable particle, lives on average 2.20×10^{-6} s, which is measured in its own frame of reference before decaying.

a) If such a particle is moving, with respect to the laboratory, with a speed of 0.900c, what average lifetime is measured in the laboratory?
b) What average distance, measured in the laboratory, does the particle move before decaying?

Question 2:
An airplane flies from San Francisco to New York (about 4800 km, or 4.80×10^6 m) at a steady speed of 300 m/s (about 670 mi/h). How much time does the trip take, as measured by an observer on the ground? By an observer in the plane?

Question 3:
A spacecraft of the Trade Federation flies past the planet Coruscant at a speed of 0.600c. A scientist on Coruscant measures the length of the moving spacecraft to be 74.0 m. The spacecraft later lands on Coruscant, and the same scientist measures the length of the now stationary spacecraft. What value does she get?

Question 4:
A proton has momentum with magnitude p_o when its speed is 0.400c. In terms of p_o, what is the magnitude of the proton's momentum when its speed is doubled to 0.800c?

Question 5:

What is the speed of a particle whose kinetic energy is equal to

(a) its rest energy and
(b) five times its rest energy?

Question 6:

An Antimatter Reactor. When a particle meets its antiparticle, they annihilate each other and their mass is converted to light energy. The United States uses approximately 1.0×10^{20} J of energy per year.

(a) If all this energy came from a futuristic antimatter reactor, how much mass of matter and antimatter fuel would be consumed yearly?
(b) If this fuel had the density of iron ($7.86\ \mathrm{g/cm^3}$) and were stacked in bricks to form a cubical pile, how high would it be? (Before you get your hopes up, antimatter reactors are a long way in the future-if they ever will be feasible.)