PH 429: Reference Frames
Relativistic Particles I

Solve the following problem on a large whiteboard

COSMIC RAYS

The collision of cosmic rays with gas nuclei in the atmosphere 60 km above the surface of the earth produces μ-mesons, which then move vertically downward at close to the speed of light. The halflife before μ-mesons decay into other particles is 1.5 μs (1.5×10^{-6} s).

Assume all the mesons are traveling straight down at the same speed.

1. Assuming it doesn't decay, what is the minimum time it would take a μ-meson to reach the surface of the earth?

2. Assuming there were no time dilation, what is the maximum fraction of the mesons that would reach the earth without decaying?

3. In actual fact, roughly $\frac{1}{8}$ of the mesons reach the earth! How fast are they going?

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Revised 2013 by Mary Bridget Kustusch

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Relativistic Particles II

Choose one of the following problems to work on a large whiteboard.

MASS ISN'T CONSERVED

Two identical lumps of clay of (rest) mass m collide head on, with each moving at $\frac{3}{5}c$. What is the mass of the resulting lump of clay?

IDENTICAL PARTICLES

Consider the head on collision of 2 identical particles each of mass m and energy E.

1. In Newtonian mechanics, what multiple of E is the energy E' of one particle as observed in the reference frame of the other?

2. In special relativity, what is the energy E' of one particle as observed in the reference frame of the other?

3. Suppose we collide 2 protons ($mc^2 = 1$ GeV) with energy $E = 30$ GeV. Roughly what multiple of E is E' in this case?

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