NYU Physics I—Problem Set 14

Due Thursday 2017 December 14 at the beginning of lecture.

Problem 1: The kinetic energy of a particle is defined to be the difference between the total energy E given by

$$E^2 = p^2\,c^2 + m^2\,c^4 \tag{1}$$

(where p is the relativistically correct momentum formula) and the rest-mass energy E_0 given by

$$E_0 = m\,c^2 \quad . \tag{2}$$

Given these formulae, make a table showing the kinetic energy of a 2 kg mass moving at the following set of speeds:

$0.01\,\mathrm{m\,s^{-1}}$ (you might have to use an approximation for this one)

$1.0\,\mathrm{m\,s^{-1}}$ (here too maybe)

$100\,\mathrm{m\,s^{-1}}$

$1.0\times10^4\,\mathrm{m\,s^{-1}}$

$1.0\times10^6\,\mathrm{m\,s^{-1}}$

$1.0\times10^8\,\mathrm{m\,s^{-1}}$

$2.0\times10^8\,\mathrm{m\,s^{-1}}$

$2.99\times10^8\,\mathrm{m\,s^{-1}}$

Give your answers in Joules.

Problem 2: From the notes at `http://cosmo.nyu.edu/hogg/sr/`, Problem 4–8.

Problem 3: From the notes at `http://cosmo.nyu.edu/hogg/sr/`, Problem 4–11.

Problem 4: From the notes at `http://cosmo.nyu.edu/hogg/sr/`, Problem 6–10.

Extra Problem (will not be graded for credit): *(a)* Forgetting about Special Relativity, and assuming just Newtonian mechanics, compute how long you would have to accelerate at acceleration $g = 10\,\mathrm{m\,s^{-2}}$ in order to reach the speed of light.

(b) A relativistically correct contstant-acceleration trajectory on a spacetime diagram is a hyperbola, where both asymptotes are 45-degree lines (null trajectories. Find a formula (position x as a function of time t) for this hyperbola, constrained to have acceleration g at small times.

(c) Show that this trajectory is unchanged under the Lorentz transformation. That is, show that if you boost in the x direction, the trajectory translates onto itself (except, possibly, for a small shift in the x or t direction).