Modern Physics 330: Exam #1

#1) A proton with total energy $E = 7$ GeV collides with a proton at rest in the lab frame. What is the total energy in the CM frame? Take the proton mass to be $m_p c^2 = 1$ GeV. It is much easier not to boost to the CM frame!

#2) Recall that the smallest energy that a Compton-scattered photon can have is when it is back-scattered and is given by,

$$E'_\gamma = \left( \frac{1 - \beta}{1 + \beta} \right) E_\gamma,$$

where $\beta$ is the boost to the CM frame. Let’s write the initial photon energy as a fraction $x$ of the electron rest energy,

$$E_\gamma = x m_e c^2.$$

What is the ratio $E'_\gamma/E_\gamma$ as a function of $x$?

#3) An excited nucleus (mass $m^* c^2$) at rest in the laboratory decays to its ground state ($mc^2$) plus a gamma ray. In terms of $m^* c^2$ and $mc^2$, what is the gamma ray energy?