PHY206 Homework. Due to be turned in on 4th April.

Question 1.

In an electron positron collider, an electron and a positron are collided such that their momenta in the lab are equal and opposite. In such a collision, the electron and the positron annihilate and produce a muon and an antimuon. The rest mass of a muon is $(106\,\mathrm{MeV})/c^2$.

(a) [2 points] What is the minimum electron energy in the lab necessary to produce the muon antimuon pair, in MeV?
(b) [2 points] Assuming that the electron rest energy can be neglected, what is the momentum of the electron, in (MeV)/c ?
(c) [2 points] What is the gamma factor for the frame of reference in which the electron is at rest? Here you will need to use the electron rest mass, which is $(0.51\,\mathrm{MeV})/c^2$.
(d) [4 points] By performing a Lorentz transform, or otherwise, work out the energy of the positron in the rest frame of the electron, in MeV. Assume that the positron mass can be neglected. What relevance does this result have to the choice of colliding beam accelerators, where the beams are bought together with equal energies and opposite momenta in the lab, compared to fixed target accelerators, where a beam of particles is collided with target particles at rest in the lab?

Question 2.

An antiproton of total energy 1.6 GeV travelling in the direction of increasing x collides with a proton at rest. The proton and antiproton annihilate, producing a pair of photons. In the lab frame, photon A emerges travelling in the direction of increasing x (parallel to the direction of incidence of the antiproton). Photon B emerges travelling in the direction of decreasing x (antiparallel to the direction of incidence of the antiproton). The proton rest mass is $(0.94\,\mathrm{GeV})/c^2$.

(a) [4 points] What are the energies of photon A and photon B in GeV ? Be sure to indicate which is which.
(b) [6 points] What are the energies of photon A and photon B in the rest frame of the incident antiproton, in GeV?