Relativity Test Problems

1) Velocity of a relativistic particle

A particle has a momentum p and an energy E, where $p=\gamma mv$.
Show that the velocity can be written as:

$$v = \frac{pc}{\sqrt{m^2c^2 + p^2}}$$

2) Velocity of particles in a particle accelerator

a) Show that for a relativistic particle (a particle moving at high speed) the velocity v can be written in terms of its deviation from the light speed c as:

$$\Delta v = c - v = \frac{c}{2}\left(\frac{m_0c^2}{E}\right)^2$$

b) What is Δv for the electrons moving in the Soleil synchrotron accelerator in Paris (electrons at energy 3 GeV) ?

c) What is Δv for protons moving in LHC (if they reach 7 TeV for each proton).

Hint: use a Taylor expansion: $\sqrt{1-x} = 1 - \frac{1}{2}x$ for small x; or any other realistic realistic approximation.
Hint: calculate all energies in units of eV.

Note: The rest mass of an electron is 511 keV/c^2 and the rest mass of a proton is 938 MeV/c^2. Here energies are expressed in eV and masses in eV/c^2. (G means Giga=10^9, T means Tera = 10^{12}).

3) Compton effect

Derive the Compton equation yourself (see notes).

This derivation is just for your fun, to see how these derivations are done. Certainly too high level for an exam