Physics 200 Problem Set 4

Problem 1

If we could convert all the mass-energy from a 1 gram Cheese-Puff into kinetic energy of a 1000kg car (initially stationary), how fast would the car be traveling?

Problem 2

A particle with mass $500MeV/c^2$ decays into two identical lighter particles, each with mass $200MeV/c^2$. If the original particle was at rest, at what speed (relative to c) do the lighter particles travel away?

Note: an *electron volt* is the amount of energy it takes to move an electron through a potential difference of 1 Volt = 1 Joule/Coulomb. This means $1eV = 1.6 \times 10^{-19}J$. The electron volt is the standard unit used to describe energies in atomic and particle physics. Masses of subatomic particles are also described by giving their mass energy in electron volts (or $MeV = 10^6eV$). For example, the mass energy of an electron is $m_ec^2 = 0.511MeV$.

Problem 3

A 20 gram space rock traveling at 0.99c strikes a 1kg asteroid, initially at rest, and is completely absorbed. Find the speed of the asteroid after impact.

Problem 4

A 1kg object traveling at 0.5c collides elastically with a 2 kg object at rest, so that the masses are unchanged in the collision. If the collision is head-on (so that the 1kg mass rebounds in the opposite direction to its initial motion), what are the velocities of the two objects after the collision?

Hint: for problems involving elastic collisions, it is simplest to transform to a frame where the total momentum is zero, figure out what the final velocities are in this frame, and then transform back to the original frame. In the center of mass frame, no calculations should be required to determine the final velocities.

Problem 5

One day at Dave's New Particle World, Dave collides an electron and a positron (a particle with the same mass as an electron but with positive charge) with equal and opposite velocity. The collision produces a new short-lived unstable particle at rest, which then decays to a tau particle (mass $1777 MeV/c^2$) and a neutrino (which we can assume to be massless). If the tau particle is observed to have energy 4000MeV, what is the mass of the new particle?

Problem 6

One day, Marge and Homer are out walking their dog when they spot a UFO. The UFO is traveling horizontally (parallel to the ground) until it is directly overhead of them, then abruptly turns and starts flying directly upwards away from them. As the UFO turns, its color appears to change from green (wavelength 510nm) to orange (wavelength 590nm). Assuming that the speed of the UFO is the same before and after it turns, how fast is the UFO going?