DAY 24 – Homework

1. A new space utility vehicle (SUV) weighs 10,000 lbs and comes equipped with an optional 500,000 Hp engine, A/C, stereo, cruise control, leather seats, etc.

   (a) Using classical physics (ignore relativity), plot speed (as a % of c) vs. time for the SUV under full power, for speeds up to 90% c.

   (b) Using relativistic physics, plot speed (as a % of c) vs. time for the SUV under full power, for speeds up to 90% c. Put both plots on the same graph.

   (c) Comment on the similarities and differences between the two graphs.

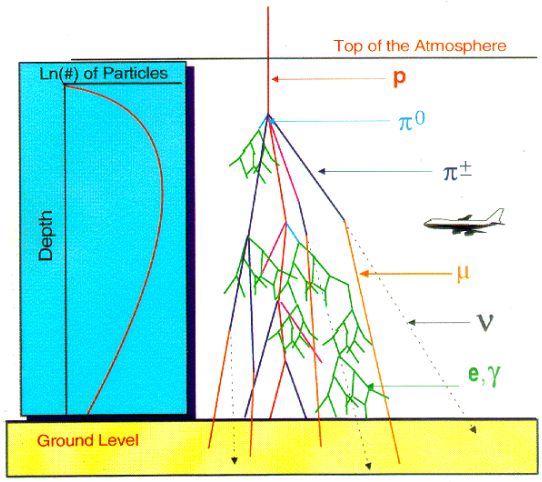
   (d) If the SUV's engine ran on direct matter-to-energy conversion, how much matter (in lbs.) would be used in accelerating the SUV to 75% c? Explain whether this makes you think high-speed travel is feasible, even if we learn how to convert matter directly to energy.

2. The power output of the Sun (Solar Luminosity) is 3.85×10^{26} W. At what rate (in kg/sec and in pickup trucks per second) is matter being converted to energy in the Sun? The Sun's mass is 1.99×10^{30} kg. How long will it take for the Sun to consume 5% of its mass?

3. Uranium-238 is radioactive, and when it decays it ejects a Helium-4 from itself and turns into Thorium-234. Determine how much mass is converted to energy when this happens. Determine the speed of the He-4 if all the energy released is in the form of kinetic energy.

Nucleus	Mass (in u)
U-238	238.050784
Th-234	234.043593
He-4	4.002602

4. The fastest Ultra-High Energy Cosmic Rays carry 1×10^{20} eV of energy, where an eV (electron-Volt) is the energy an electron gains when passing through a potential difference of 1 Volt. At what speed is a 10^{20} eV proton moving? If such a proton crossed the Milky Way galaxy (diameter roughly 70 light-years), what would it measure the galaxy's diameter to be?



Extensive Air Showers

http://www.physics.adelaide.edu.au/astrophysics/cr_new.html

5. An electron and a positron (an antimatter particle identical to electron but opposite in charge) meet, annihilating each other. If both were traveling at 90%c, how much energy was released by this annihilation?

6. Sketch a graph of the speed of a particle with respect to time if a constant force acts to accelerate it. This does not necessarily require calculations.

7. a) A space ship approaching a planet is traveling at 80% c with respect to the planet. It launches a probe toward the planet at 80% c measured with respect to the ship. At what speed is the probe approaching the planet as measured with respect to the planet?

   b) A space ship leaving a planet is traveling at 80% c with respect to the planet. It launches a probe toward the planet at 80% c measured with respect to the ship. At what speed is the probe approaching the planet as measured with respect to the planet?

8. Show that, if a truck is moving at speed v with respect to a road and turns on its headlights, the relativistic velocity addition equation is consistent with the idea that the speed at which the light will travel when seen by a roadside observer is c regardless of the speed of the truck.