PHY312 - Homework 3

1. An object of mass 3 kilograms moves 8 meters along the x-direction in in 3×10^{-8} secs as measured in the laboratory. What is its energy and momentum ? Its rest energy ? Its kinetic energy ? What value of the kinetic energy would Newton predict for this object ?

2. A proton whose rest mass is 1.67×10^{-27} kg travels at a speed of $0.99c$ relative to the laboratory. What are the energy and momentum as measured in the laboratory? Suppose another observer watches the proton from a rocket travelling at $v = 0.5c$ in the same direction as the proton. What are the values of the energy and momentum that this observer would measure ?

3. A stationary nucleus A decays radioactively into two pieces C and D. The mass of A is 20 proton rest masses $20m$, while the mass of C is 2 proton rest masses and its energy is measured to be equal to the energy of 5 proton rest masses.

   (a) What is the total energy E_A of the nucleus A in terms of m and c ?

   (b) Using conservation of energy find the total energy of particle D.

   (c) Using the expression $E^2 - c^2p^2 = m^2c^4$ find the momentum of particle C.

   (d) From conservation of momentum find the momentum of particle D.

   (e) What is the rest mass of particle D ?

   (f) Does $M_C + M_D$ after the decay equal M_A before the decay ? Explain your answer.

4. Luminous energy from the Sun pours down on the outer atmosphere of Earth at a rate of 1372 watts per square meter of area that lies at 90 degrees to the direction of this radiation. The radius of the Earth equals approximately 6.4×10^6 meters and the Earth-Sun distance equals 1.5×10^{11} meters. The mass of the Sun is approximately 2.0×10^{30} kilograms.

   (a) How much mass is converted to energy every second in the Sun to supply the luminous energy that falls on the Earth ?

   (b) What total mass is converted to energy every second in the Sun to supply luminous energy ?

   (c) Most of the Sun's energy comes from burning hydrogen nuclei (mostly protons) into helium nuclei (mostly a 2 proton - 2 neutron reaction combination). Mass of the proton equals 1.67262×10^{-27} kg and mass of helium equals 6.64648×10^{-27} kg. How many kilograms of hydrogen must the Sun convert to helium every second to supply its luminous output ?

   (d) Estimate how long the Sun will continue to warm the Earth neglecting all other processes in the Sun