PHY4116 From Newton to Einstein
Coursework Sheet 10: Relativistic momentum and energy

Date issued: 5th December 2012 Hand in by 4pm, 10th December 2012

---

1) a). At what speed is the momentum of a particle twice as great as the result obtained from the non-relativistic expression $p = mv$? Express you answer in terms of the speed of light. b). A force is applied to a particle along its direction of motion. At what speed is the magnitude of the force required to produce a given acceleration twice as great as the force required to produce the same acceleration when the particle is at rest? Express your answer in terms of the speed of light. [4]

2) A proton (rest mass 1.67×10^{-27} kg) has a total energy that is 4 times its rest energy. What is a) the kinetic energy of the proton? b) the magnitude of the momentum of the proton? c). The speed of the proton? [3]

3) Two protons, each with a rest mass of 1.67×10^{-27} kg, are initially moving with equal speeds in opposite directions. The protons continue to exist after a collision that also produces a η^0 particle. The rest mass of the η^0 9.75×10^{-28} kg. a). If the two protons and the η^0 are all at rest after the collision, find the initial speed of the protons, expressed as a fraction of the speed of light. b). What is the kinetic energy of each proton? Express your answer in MeV. c). What is the rest energy of the η^0, expressed in MeV? d). Discuss the relationship between the answers to parts (b) and (c). [5]

4) The Sun produces energy by nuclear fusion reactions, in which matter is converted into energy. By measuring the amount of energy we receive from the Sun, we know that it is producing energy at a rate of 3.8×0^{26} W. a). How many kilograms of matter does the Sun lose each second? [1]

5) A pion (π^+) which is at rest, decays into a muon (μ^+) and a neutrino (ν). The mass of the muon is 106 MeV/c^2 and its kinetic energy is 4.6 MeV. Given that the neutrino has negligible mass find the mass of the pion. [2]