Problems 2-36

Q1: For an exteremely relativistic particle of rest energy $E_0 = m_0 c^2$, show that the momentum p is given by $pc = E\left[1 - \frac{1}{2}\left(\frac{E_0}{E}\right)^2\right]$ to a good approximation.

Q2: At what fraction of the speed of light does a particle travel if its kinetic energy is twice its rest mass energy.

Q3: Calculate the momentum of a neutron (rest mass 940 MeV) whose kinetic energy is 200 MeV.

Q4: What is the ratio of the relativistic mass to the rest mass for (a) an electron (b) a proton when it is accelerated from rest through a potential difference of 15 megavolts. Take $m_e = 0.511$ MeV, $m_p = 1000$ MeV.

Q5: Prove that the velocity of a particle can be written as $\vec{v} = \frac{c^2}{E}\vec{p}$ and its magnitude as $v = \frac{dE}{dp}$.

Q6: Calculate the speed of an electron (rest mass 0.511 MeV) that has been accelerated through a potential difference of 2×10^6 V
(a) Classically (b) Relativistically.
Calculate the electron mass in case (b)

Q7: A particle has a total energy of 5 GeV and a momentum of 3 GeV/c in a certain frame of reference. (a) Find its energy in a frame in which its momentum is 4 GeV/c. (b) Calculate the rest mass of the particle.

Q8: An electron moves in a circle 0.4 m diameter in a uniform magnetic field of 0.03T. Obtain the speed and kinetic energy of the electron. Take $m_0c^2 = 0.511$ MeV.

Q9: Calculate the radius of curvature of a proton of velocity $0.1c$ in a magnetic field of 1 Tesla (Take $m_p c^2 = 1020$ MeV).

Q10: Show that the speed v of an extremely relativistic particle differs from the speed of light c by

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

Find Δv for an electron of kinetic energy K (a) 100 MeV (b) 25 GeV. Take $m_0c^2 = 0.511$ MeV.