Series of Exercises 03

Relativistic Dynamics

Data:
$1u.m.a = 1.660538921 \times 10^{-27}[kg]$; $m_p = 1.0073u$; $m_n = 1.0087u$; $m_e = 5.489 \times 10^{-4}u$;
$c = 299792458[\mathrm{m}.s^{-1}]$

Exercise 01:

Calculate the necessary speed (as a fraction of light celerity c) of an accelerated electron in laboratory, to make it see its own mass grown by a factor γ as shown in the following table:

γ	*2*	*5*	*10*	*20*	*100*	*500*	*1000*	*2000*
$\beta = v/c$								

Exercise 02:

1. For a given high energy particle $(E \gg E_0)$, show that its momentum could be given by the following expression:

$$pc = E\left(1 - \frac{1}{2}\left(\frac{E_0}{E}\right)^2\right)$$

2. Examine the case of an accelerated electron reaching the following energies (MeV): 1.022; 5.11; 51.1

Exercise 03:

Calculate the momentum of a proton with a kinetic energy given by $T = 200MeV$.

Exercise 04:

What is the ratio m/m_0 for:
(a) Electron
(b) Proton
When it is accelerated from the rest to reach a kinetic energy of 15 MeV?

Exercise 05:

1. Show that we can write the velocity vector of a given particle as: $\vec{v} = \frac{c^2}{E}\vec{p}$
2. Show that the magnitude of this velocity could be given by: $v = dE/dp$

Exercise 06:

1. Calculate the rest energy of the atomic mass unit $m_0 = 1u.m.a$
2. A particle with a total energy of $5GeV$, has a momentum $p_1c = 3GeV$ in a first frame. What is its energy in a second frame in which $p_2c = 4GeV$?
3. What is the rest mass of this particle?
4. Deduce its kinetic energy in both frames.

Exercise 07:

For an accelerated electron under a potential difference $\Delta U = 2 \times 10^6 V$; calculate its speed by using both classical and relativistic expressions. Comment.

Exercise 08:

Consider a particle with a momentum $p = m_0 c$.

1. Calculate its velocity.
2. Calculate its mass.
3. Calculate its kinetic energy

Exercise 09:

The nucleus of deuterium ${}^2_1H$ is made from one proton and one neutron. Its rest mass is $m_D = 2.01375u$.

1. Compare this mass to the sum $m_p + m_n$.
2. What is this difference in terms of energy equivalent?
3. What did this difference represent (in %) compared to the rest mass of the deuterium?
4. What did this difference represent physically for the ${}^2_1H$ nucleus?

Exercise 10:

The solar radiations reach the surface of Earth with an average power of $1.34 \times 10^3 [W.m^{-2}]$. Knowing that the average distance Sun-Earth is $R = 1.49 \times 10^{11} m$ and the rest mass of the sun is estimated to be $M_S = 2 \times 10^{30} kg$.
Find the rate in which the Sun lose its rest mass due to emitted radiations.