University of Sri Jayewardenepura
B.Sc. General/Special Degree Second Year Second Semester Examination
November 2016
PHY 207 1.0 Special Theory of Relativity
Time: - One (01) hour

Answer all questions.

Assume, speed of Light (c) = 3.0×10^8 ms^{-1}

01. a). Derive the expression $E^2 = c^2p^2 + E_0^2$ using the mass-energy-momentum relationships and mass-energy equivalence. All symbols have their usual meanings.

b). Hence, show that the kinetic energy K of an object moving with a constant speed v can be written as

$$K = m_0c^2\left(\frac{1}{\sqrt{1-{v^2}/{c^2}}} - 1\right).$$ All symbols have their usual meanings.

c). The mean life-time of muons at rest is 2.2×10^{-6} s. The observed mean life-time of muons as measured in the laboratory is 6.6×10^{-6} s.

Find

(i). The effective mass of a muon at this speed when its rest mass is $207m_e$

(ii). Its kinetic energy

(iii). Its momentum, where m_e is the mass of an electron.

02. a). Obtain an expression for the length contraction $\left(L = L_0 \left(\sqrt{1 - {v^2}/{c^2}}\right)\right)$

for an object moving with velocity v along its length L_0.

b). A meter stick in frame $S^{/}$ makes an angle of 30 ^{0} with the $x^{/}$ axis. If that frame moves parallel to the x axis of frame S with velocity $0.90c$ relative to the frame S , what is the length of the stick as measured from S.

c). An electron of β = 0.9999 moves along the axis of an evacuated tube that has a length of 2.6 m as measured by a laboratory observer S at rest relative to the tube. An observer $S^{/}$ at rest relative to the electron, however, would see this tube moving with speed v $(= \beta c)$. What length would observer $S^{/}$ measure for the tube?

03. a). Derive an expression for the time dilation effect

(i.e., relativistic time, $\tau = {1}\Big/{\sqrt{1 - {v^2}/{c^2}}}\,\tau_0$) for an object moving with speed v

with respect to an inertial reference frame at rest.

b) The half-life of muons is 1.53 x 10^{-6} s as measured in the laboratory frame of reference. But, the half-life of muons in cosmic rays is 6.40 x 10^{-6} s.

(i). Explain this time difference

(ii) Find the velocity of muons in the Cosmic rays.

c). Particle X, which is created in a particle accelerator, travels a total distance of 100.0 m between two detectors in 410 ns as measured in the laboratory frame before decaying into other particles. What is the life time of the particle X as measured in its own frame.