B. Sc. Part I
Paper I

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~~R~~ Theory of Relativity

Volume ...

Problem :- The life of μ-mesons is 2.2×10^{-6} sec. and their speed is $0.999c$; so that they cover only a distance of $0.998c \times 2.2 \times 10^{-6}$ or 658.6 metres in their entire life time and yet they are found in profusion at sea level, i.e., at a depth of 10 km from the upper atmosphere where they are produced. How may this be explained on the basis of (i) Lorentz- Fitzerald Contraction. ii) time dilation.

Sol :- (i) Here 2.2×10^{-6} sec is the proper mean life time and the distance covered by them during this time $= 658.6$ m.

The distance traversed by them as observed from earth

$$l = \frac{l_0}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}} = \frac{658.6}{\sqrt{\left[1-\left(\frac{0.998c}{c}\right)^2\right.}}$$

$$= \frac{658.6}{0.064} = 10290\ m = 10.29\ Km$$

Thus μ-mesons can cover a distance of 10 Km or more despite their short life time. This expains their presence at sea level on the basis of length contraction.

(ii)

The observed life of μ-mesons

$$\Delta t' = \frac{\Delta t}{\sqrt{(1-v^2/c^2}}$$

$$= \frac{2.2\times10^{-6}}{\sqrt{\left[1-\left(\frac{0.998c}{c}\right)^2\right.}}$$

$$= \frac{2.2\times10^{-6}}{0.064}\ sec$$

$$= 34.6\times10^{-6}\ sec$$

i.e; distance covered in this time

$$= v\Delta t' = 0.998c \times 34.36\times10^{-6}$$

$$= 10290\ m$$

$$= 10.29\ Km$$

This explains their presence at sea level on the basis of time dilation.

Teacher's Signature ____________

4.) Relativity of time; Proper time :-

The time recorded by a clock moving with a given system is called Proper time for That system.

Let there be two systems S and S', S' moving with a velocity v relative to The system S along (+)ve direction of x-axis. Imagine The system S' to be an aeroplane moving with velocity v and an observer is in the aeroplane and the other system S, i.e., at rest. Let The observer at rest measure the time t for The journey of The observer in the aeroplane and if t' is The corresponding time recorded by The observer in The Plane, Then according to Lorentz transformation equations,

$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{(1-\beta^2)}}$$

Since t is The time recorded by an observer at rest and v is The velocity of The Plane, Therefore

$$x = vt \qquad (\because \text{distance} = \text{velocity} \times \text{time})$$

Putting this value in above equation, we get

$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{(1-\beta^2)}} = \frac{t(1 - v^2/c^2)}{\sqrt{(1-\beta^2)}}$$

$$= \frac{t(1-\beta^2)}{\sqrt{(1-\beta^2)}} = t\sqrt{(1-\beta^2)}$$

<u>or</u> $$t' = t\sqrt{\left(1-\frac{v^2}{c^2}\right)}$$

So That $t > t'$

Thus time recorded by the two clocks in two system S and S' for the same journey are different i.e., two clocks in the two system S and S' run at different rates. we thus conclude that there are two proper times, one for observer in system S and other for observer in S'. we have the time recorded in system S to be greater than that system S'. By the principle of relativity we have observer in S' to be at rest relative to the plane and the observer in S has a velocity v relative to the plane. Conclusively "A moving clock runs more slowly than a stationary one." Also time is not absolute as considered in Galilean transformations; but relative only.