**Shambhunath institute of engineering and technology**

 **assignment unit -1 (Relativistic Mechanics)**

1. Discuss the objective of Michelson Morley experiment. Describe this experiment. State it with negative results.
2. Show from Lorentz transformation two events simultaneous (t1=t2) at different positions (x1≠ x2) in a reference frame S are not in general simultaneous in another frame S’.(HINT: x2 + y2 +z2 – c2t2 is invariant under Lorentz transformation).

Or

 Show that space time or interval between two events remains invariant under Lorentz

 Transformation. i.e. x2 + y2 +z2 – c2t2 is invariant under Lorentz transformation.

1. Derive Lorentz transformation equations. On the basis of Lorentz transformation equations also derive length contraction and time dilation.
2. Derive an expression for the variation of mass with velocity.

 Or

Show how the relativistic invariance of the law of conservation of momentum leads to the concepts of variation of mass with velocity.

1. Derive the velocity addition formula and using the same show that no signal can travel faster than velocity of light.

Or

Deduce the relativistic velocity addition theorem or the addition of the relativistic velocities. Show that it is consistent with Einstein’s second postulate i.e velocity of light is invariant.

1. Prove that $\left(i\right) E^{2}-p^{2}c^{2}=m\_{0}^{2}c^{4}$

 (ii) F = mo$ \frac{dv}{dx}$ (1- $\frac{v^{2}}{c^{2}}$ )-3/2

 (iii) $K=m\_{0}$ $c^{2}\left[\left(1-\frac{v^{2}}{c^{2}}\right)^{-\frac{1}{2}}-1\right]$

 (iv) E = pc for photon.

 (v) P = $\sqrt{\frac{K\_{E}^{2}}{c^{2}}+2m\_{0}K\_{E}}$

1. Derive an expression for the mass energy equivalence relation. Also write the experimental verification or evidence of mass energy equivalence.
2. Short notes on :
* Which particle has zero rest mass and show this using mass variation formula.
* Inertial and non inertial frame of reference.
* Explain objective, negative result & its interpretation and conclusion of negative results of Michelson Morley exp.
* Write experimental verification of time dilation and mass energy equivalence.
* Acceleration is invariant under Galilean transformations.
* Earth is inertial or non inertial frame.
* Show for slow speed, relativistic K.E (m –mo)c2 reduces to classical K.E i.e $\frac{1}{2}m\_{0}v^{2}$
* No signal or object can travel with the velocity of light.
1. A circular lamina moves with its plane parallel to x-y plane of reference frame S at rest. Assuming its motion to be along the axis of x, calculate the velocity, at which its surface area would appear to be reduced to half to an observer in frame S at rest.
2. Show that a circle $x^{2}+y^{2}=a^{2}$ in a frame S will appear an ellipse in frame S’ moving with velocity v with respect to frame S.
3. How much does a proton gain in mass when accelerated to a kinetic energy of of 500 MeV.
4. The mean life of meson is 2 x 10-6 sec. calculate the mean life of meson in speed 0.8c.
5. If $L\_{0}^{3}$ is the rest volume of a cube then show that $L\_{0}^{3}\sqrt{1-\frac{v^{2}}{c^{2}}}$ is the volume viewed from a reference frame moving with uniform velocity (i) v and (ii) 0.7c in a direction parallel to an edge of the cube. What is the new shape of cube in fast speed?
6. Calculate the rest mass, relativistic mass and momentum of photon having energy 5eV. $Ans:8.9×10^{-36}kg, zero,2.67×10^{-27}kg.m/s$
7. Calculate the percentage contraction of a rod moving with the velocity of 0.8c in a direction inclined at 600 to its own length. (hint: only horizontal component contract) $Ans:8.4\%$
8. How fast must an electron move such that its rest mass becomes equal to the rest mass of a proton? $v=2.99×10^{8}m/s or v=c$
9. A nucleus of mass m emits a γ- photon of frequency ѵ0. Show that the loss of internal energy suffered by the nucleus is not hѵ0 but $hv\_{0}\left[1+\frac{hv\_{0}}{2mc^{2}}\right]. $
10. A particle of mass m0 moves with speed c/√2. Calculate the mass, momentum, total energy and kinetic energy of particle.

 $Ans :m=1.41m\_{0},P=m\_{0}c,E=1.41m\_{0}c^{2},K=0.41m\_{0}c^{2}$

1. Calculate the work done to increase the speed of electron of mass 0.5 MeV from 0.6c to 0.8c. $Ans :dw=K\_{2}-K\_{1}=3.36×10^{-14}joule$
2. Find the speed of 0.1 MeV electrons according to classical and relativistic mechanics. Ans: 1.87 x 108 m/s , 1.64 x 108 m/s
3. The mass of a moving electron is 11 times its rest mass. Calculate its kinetic energy and momentum. $Ans:K=5.12×10^{6}eV, P=3×10^{-21}kgm/s$
4. A meter rod is projected into space at such a high speed that its length appears 50 cm. How fast is it moving? $ Ans: v=\frac{\sqrt{3}}{2} c or 2.6×10^{8}m/s $
5. How fast would a rocket have to go relative to an observer for its length to be contracted to 99% of its length at rest? $Ans:0.141c or 4.23×10^{7}m/s $
6. Calculate the percentage contraction of a rod moving with a velocity of 0.9c in a direction at 450 to its own length. $Ans:22.8\%$
7. In the laboratory, lifetime of a particle moving with speed 2.8x1010cms-1 is found to be 2x10-7 s. Calculate the proper life time of the particle. $Ans:7.18×10^{-8}s$
8. At what speed should a clock be moved so that it may appear to lose 1 minute in each hours. $Ans:5.4×10^{7}m/s$
9. Two particles come towards each other with a speed of 0.9c. What is their relative speed? $Ans:0.99c$
10. Two photons are traveling in opposite direction. Determine their relative velocity.

 $Ans:v=c$

 $Ans: u=c=3x10^{8}m/s$

**GIVEN: mass of electron: 9.1 x 10-31 kg**

 **Mass of proton: 1.67 x 10-27 kg**

 **1 eV = 1.6 x 10-19 joule**

 **Mass of α particle = 4 mass of proton.**