B.Sc. I University of Allahabad

RELATIVITY

Questions Asked in Examination (2008-2020)

1. (a) Derive Lorentz transformation equations.
   (b) Find the increase in the mass of a particle of rest mass 1 g when it is moving with speed 0.8c. Hence, find its kinetic energy.
2. (a) Write down the Lorentz transformation equations and show if V<<c, it changes to Galilean transformation equations.
   (b) Obtain the velocity addition theorem.
3. For Lorentz transformations when inertial frame S' moves with respect to inertial frame S along x-direction with velocity v,
   (i) Explain why the transformation relations giving x', y', z', t' in terms of x,y,z, t are linear.
   (ii) Prove that x' has the form x'= a_{11}(x-vt), y'=y and t' is of the form t'=a_{41}x+a_{44}t. Also, if a particle moves along x direction with velocities Ux and U'x in the frames S and S', show that (iii) U'x=(Ux-V)[1-Uv/c^2].
4. (a) What is length contraction? If L_0^3 is the rest volume of a cube then show the volume viewed from a reference frame moving with uniform velocity v in a direction parallel to an edge of the cube is $L_0^3\sqrt{(1-\beta^2)}$, where $\beta = \frac{v}{c}$.
   (b) Deduce an expression for the kinetic energy of a relativistic particle.
5. Discuss Einstein's mass-energy relation.
6. Prove that (a) $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$, (b) $\vec{F} = m\frac{d\vec{u}}{dt} + \frac{1}{c^2}\vec{u}(\vec{F}.\vec{u})$, where symbols have their usual meaning, (c) $E = m_0c^2 + K$, (d) $K^2 + 2Km_0c^2 = p^2c^2$, and (e) $K = \frac{p^2}{m+m_0}$.
7. (a) Show that the momentum of a relativistically moving particle of rest mass m_0 and kinetic energy, K_E is given by the expression $p = \sqrt{\frac{K_E^2}{c^2} + 2m_0K_E}$.
   (b) Prove that the particle of zero rest mass moves with the speed of light.
   (c) Show that two successive Lorentz transformation in the same direction is equivalent to a single Lorentz transformation in the same direction.
8. (i) Show that the relativistic particles
   (a) Kinetic energy $K = mc^2 - m_0c^2$, where m is relativistic mass and m_0 is the rest mass.
   (b) $\frac{dE}{dp} = u$, where E is the total energy of the particle and p is the momentum along the line of motion.
   (ii) Intertial frame S' is moving with velocity v with respect to the in inertial frame S along the common x-x' direction. In frame S' a passenger is moving with a velocity $\vec{u}$. Obtain the expression for $u_{x'}$, $u_{y'}$ and $u_{z'}$, while the passenger's velocity components in frame S are u_x, u_y and u_z.
9. Write a short note on the following:
   a. The relativity of simultaneity of Events
   b. Lorentz Transformation Equations

c. Simultaneity in relativity theory
d. Mass-energy equivalence
e. Michelson-Morley experiment
f. Relativistic velocity transformation equations.
g. Lorentz transformations

10. A passenger in a train is moving with some velocity and the velocity of the train with respect to the ground is V. What will be the velocity of the passenger as measured from the ground if the passenger happens to be a signal of light beam?
11. An electron (rest mass 9.1×10^{-31} kg) is moving with a speed of 0.8c ($c=3\times10^{8}$ m/s). Calculate its total energy.
12. An event takes place at the origin at t=0 and another at point x=100 cm at $t=10^{-9}$ sec. What shall be the velocity of an observer so that the two events appear simultaneous to him?
13. An electron is moving with a speed of 0.9c. (i) What is its total energy. and (ii) Find the ratio of Newtonian kinetic energy to the relativistic kinetic energy.
14. A particle of mass m_0 travelling with a speed 0.6c collides with an identical particle at rest and sticks to it. Find the velocity of the resulting particle.
15. An event takes place at origin at t=0 another at point (2,0,0) m at 10^{-9} s. What would be the velocity of an observer so that the two events appear simultaneous to him.