Question bank on Classical mechanics and special theory of relativity

Semester-III

1. (i) Calculate the distance travelled by a particle during one mean life if it travels with a speed of 2.22 x10^{10} cm/sec. [Proper mean life =2.5x10^{-8}s].

(ii) State Einstein's postulate for special theory of relativity which related with Michelson-Morley experiment.

(iii) Using Lorentz transformations obtain the expression for time dilation. What is proper time?

(iv) Obtain the relation between mass and velocity of a relativistic particle.

(v) Hence prove that kinetic energy of the relativistic particle is T = $mc^2+m_oc^2$ where m_o is rest mass.

(vi) Obtain Einstein's velocity addition theorem.

Show that Lorentz transformation can be regarded as rotation of axes through an imaginary angle $\theta=\tan^{-1}(i\ \beta)$ where $\beta=v/c$.

2. (i) What do you mean by holonomic and nonholonomic constraints?

(ii) A particle is constrained to move on a spherical surface. Write down the equation of constraint. Mention the number of degrees of freedom and generalized co-ordinates of the system.

(iii) Show that conjugate momentum of a cyclic coordinate is a conserved quantity.

3. (i) Define virtual displacement and virtual work. State principle of virtual work. Hence obtain D'Alembert principle.

(ii) Write down the Lagrangian of a compound pendulum and hence obtain the Lagrange's equation of motion.

4. (i) Define Hamiltonian of a system. Hence obtain Hamilton's equation of motion.

(ii) Show that the Hamiltonian of a conservative system is total energy of the system.

(iii) Show that the Lagrange's equation of motion remains unaltered if it is added to a constant.

5. (i) Mention whether the constraint x dy + y dx = c dx + f dy is holonomic or not.

(ii) A uniformly heavy flexible string is fixed at two ends. Find the equation of the curve describing the form of the state.

6. (i) The Lagrangian of a system is $L=\dot{q}_1{}^2+\dot{q}_2^2+\dot{q}_1\dot{q}_2-q_1{}^2-q_2^2$. Obtain the equation of motion.

(ii) Prove that total angular momentum of a closed system remain constant in isotropy in space.

(iii) What is action and Hamilton's principle of least action? Obtain Lagrange's equation of motion from the principle.

7. (i) Obtain Lagrange's equation for a holonomic conservative system from D' Alembert's principle.

(ii) Show that for a conservative system in which the Lagrangian is not an explicit function of time, Hamiltonian is conserved.