

2023-24

Time - 3 hours

Full Marks - 80

*Answer all groups as per instructions.
Figures in the right hand margin indicate marks.
Candidates are required to answer
in their own words as far as practicable.*

GROUP - A

1. Fill in the blanks. (all)

[1 × 12

- (a) Generalized co-ordinates are _____ of each other.
- (b) The Lagrangian equation of motion in conservative system is _____.
- (c) Time period of compound pendulum is _____.
- (d) The shortest distance between two points in a plane is a _____.
- (e) The nature of path followed by a particle in Brachistochrone problem is _____.
- (f) Hamiltonian (H) represents _____ of the system for a conservative system.

[2]

- (g) A point in Minkowski space is called as _____.
- (h) If the body moving with velocity comparable to the velocity of light, then the mass of the body is _____.
- (i) The expression for the relativistic energy of a particle is _____.
- (j) The speed of light in free space has the _____ value in all inertial frame of reference.
- (k) The real intervals between events are referred to as _____ like interval.
- (l) A vector in four dimensional _____ space is called as a four vector.

GROUP - B

2. Answer any eight of the following within two or three sentences each. [2 × 8]
- (a) Define generalized displacement.
- (b) Write the Lagrangian equation of a linear Harmonic Oscillator.
- (c) Define virtual displacement.
- (d) What do you mean by cyclic co-ordinates ?

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- (e) What are the Hamiltonian equation of motion ?
- (f) Give the condition for light like interval.
- (g) State two postulates of special theory of relativity.
- (h) What is the physical significance of Hamiltonian ?
- (i) Define four dimensional position vectors.
- (j) Compute the speed of a particle whose kinetic energy is double its rest energy.

GROUP - C

3. Answer any eight of the following within 75 words each. [3 × 8]
- (a) Define generalized acceleration.
- (b) Derive D'Alembert's principle from the principle of virtual work.
- (c) Derive Lagrangian equation of motion of an Atwood's machine.
- (d) Derive Hamiltonian equation of motion of a particle moving under central force.
- (e) Prove that $x^2 + y^2 + z^2 = c^2t^2$ is invariant under Lorentz transformation equation.
- (f) Explain Twin Paradox.

[4]

- (g) What are inverse Lorentz transformation equations ?
- (h) Two space vehicles travel in opposite directions with velocity $0.9c$. Find the relative velocity.
- (i) The relativistic mass of an object is 10% larger than its rest mass. Find the speed of the object.
- (j) Derive Galilean transformation equations.

GROUP - D

4. Answer any four of the following within 500 words each. [7 × 4]
- (a) Derive Lagrange's equation of motion for compound pendulum.
 - (b) Derive Lagrange's equation of motion for Dumb-bell.
 - (c) Derive Lagrange's equation of motion from variational principle.
 - (d) Derive Euler-Lagrange differential equations.
 - (e) Explain length contraction and time dilation.
 - (f) State and explain Lorentz transformation equation.
 - (g) State and explain relativistic Doppler's effect.
 - (h) Derive the expression for four velocities and four accelerations.