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# 752102

**January 2023**

**M.Sc. (Physics) Ist SEMESTER**

**Classical Mechanics (MPH 102)**

Time: 3 Hours]

[Max. Marks. : 75

*Instructions :*

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*

## PART-A

1. (a) Discuss with examples different types of constraint of motion. (1.5)

   (b) At what speed, the mass density of an object will increase by 25% of its rest mass. (1.5)

   (c) Define Kepler's 2nd law of motion. (1.5)

   (d) What is length contraction? (1.5)

   (e) What is physical significance of the Hamiltonian? (1.5)

   (f) Explain the concept of Poisson's Bracket. (1.5)

(g) How many numbers of non-zero frequency normal modes exist for a system of 12 degree of freedom? (1.5)

(h) State Liouville's theorem. (1.5)

(i) State the parameters which determine the slope of the orbit. (1.5)

(j) Define Virial theorem. (1.5)

## PART-B

**2.** (a) What do you mean by canonical transformations? Derive the expression for 2nd and 3rd form of canonical transformation. (8)

(b) Derive an expression for the Lagrangian equation of motion for Atwood machine. (7)

**3.** (a) Show that the transformation equation :

$P = 2(1 + q^{1/2} \cos p)\, q^{1/2} \sin p$ and $Q = \log (1 + q^{1/2} \cos p)$ is canonical. (5)

(b) Generating function of this transformation is $F_3 = -(e^Q - 1)^2 \tan P$. (5)

(c) Prove that if transformation functions are not explicit function of time, then the Kinetic energy is homogeneous quadratic function of generalized velocities. (5)



**4.** (a) Prove that $[J_x, p_x] = 0$ and $[J_y, J_z] = J_x$. (5)

(b) State and Prove Principle of least action. (5)

(c) Define Lagrange's bracket and show that the Lagrange's bracket is canonical invariant. (5)

**5.** (a) Show that for a free particle of small mass moving on a straight line, the Hamiltonian-Jacobi equation reads as $\frac{\partial S}{\partial t} + \frac{1}{2}\left(\frac{\partial S}{\partial q}\right)^2 = 0$. (5)

(b) How will you reduce two body problem in one body problem and explain the concept of reduced mass also. (5)

(c) Find the central force under the action of which the particle will follow an orbit described by $r = a(1 + \cos \theta)$. (5)

**6.** (a) Derive mass-energy equivalence relation. Explain physical significance of this relation. (5)

(b) Apply Lorentz Transformation to derive an expression for

(i) Length Contraction. (5)

(ii) Time Dilation. (5)