REV-01
MSP/15/20

2023/12

SET A

M.Sc. PHYSICS
FIRST SEMESTER
CLASSICAL MECHANICS
MSP – 103

[USE OMR FOR OBJECTIVE PART]

Duration: 1:30 hrs. **Full Marks: 35**

Objective

Time: 15 mins. **Marks: 10**

Choose the correct answer from the following: ***1×10=10***

1. The generalized force for a conservative potential system $V = \frac{1}{2} {q_k}^2$
   a. q_k b. $-q_k$
   c. $2q_k$ d. $-2q_k$

2. The kinetic energy of a particle of mass m will be $T = \sum \frac{1}{2} m_k \, {\dot{q}_k}^2$. Its canonical momentum will be
   a. $p_k = -\sum m_k \dot{q}_k$ b. $p_k = \sum m_k \dot{q}_k$
   c. $p_k = -2\sum m_k \dot{q}_k$ d. $p_k = 2\sum m_k \dot{q}_k$

3. The Hamiltonian of a system is $H = \frac{p^2}{2m} + V$. Its Lagrangian will be
   a. $L = \frac{1}{2} m\dot{q}^2 + V$ b. $L = m\dot{q}^2 + V$
   c. $L = \frac{1}{2} m\dot{q}^2 - V$ d. $L = m\dot{q}^2 - V$

4. The Lagrangian of system is $L = \frac{1}{2} m \, \dot{z}^2 - mgz$. The Lagrange equations of motions will be
   a. $m\ddot{z} - m\, g = 0$ b. $m\ddot{z} + mg = 0$
   c. $m\ddot{z} + g\, z = 0$ d. $m\ddot{z} + mg\, z = 0$

5. The effective potential energy of a charged particle in an electromagnetic field is
   a. $U = q(-\phi - \vec{v} \cdot \vec{A})$ b. $U = q(-\phi - \vec{v} \cdot \vec{A})$
   c. $U = q(\phi - \vec{v} \cdot \vec{A})$ d. $U = q(\phi + \vec{v} \cdot \vec{A})$

6. The Hamiltonian equations of motions is
   a. $\dot{p}_k = -\frac{\partial H}{\partial q_k}$ b. $\dot{p}_k = \frac{\partial H}{\partial q_k}$
   c. $\dot{p}_k = -\frac{\partial H}{\partial q_k}$ d. $\dot{p}_k = \frac{\partial H}{\partial q_k}$

7. The Lagrangian of a system corresponding to the Hamiltonian $H = \frac{{p_r}^2}{2m} + \frac{{p_\theta}^2}{2mr^2}$
   a. $\frac{1}{2} m \, (\dot{r}^2 - r^2\dot{\theta}^2)$ b. $\frac{1}{2} m \, (\dot{r}^2 + r^2\dot{\theta})$
   c. $\frac{1}{2} m \, (\dot{r}^2 + r \, \dot{\theta}^2)$ d. $\frac{1}{2} m \, (\dot{r}^2 + r^2\dot{\theta}^2)$

8. The velocity of a charged particle in an electromagnetic field is
   a. $\vec{v} = \frac{1}{m}(\vec{p} - \vec{A})$ b. $\vec{v} = \frac{1}{m}(\vec{p} - q\vec{A})$
   c. $\vec{v} = \frac{1}{m}(\vec{p} + q\,\vec{A})$ d. $\vec{v} = \frac{1}{m}(\vec{p} + \vec{A})$

9. A particle moves under the action of a generalized potential V (q, $\dot{q}$) = $\frac{1+\dot{q}}{q^2}$. The magnitude of the generalized force is

a. $\frac{2(1+q)}{q^3}$
b. $\frac{2q}{q^3}$
c. $\frac{2}{q^3}$
d. $\frac{2(1-\dot{q})}{q^3}$

10. The Lagrangian of a spherical pendulum is

a. $L = \frac{1}{2}m\,l^2(\dot{\theta}^2 + sin^2\theta\,\dot{\varphi}^2) + mgl\,sin\theta$
b. $L = \frac{1}{2}m\,l^2(\dot{\theta}^2 + sin^2\theta\,\dot{\varphi}^2) - mgl\,cos\,\theta$
c. $L = \frac{1}{2}m\,l^2(\dot{\theta}^2 + sin^2\theta\,\dot{\varphi}^2) - mgl\,sin\theta$
d. $L = \frac{1}{2}m\,l^2(\dot{\theta}^2 + sin^2\theta\,\dot{\varphi}^2) + mgl\,cos\,\theta$

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Descriptive

Time : 1 hr. 15 min. Marks : 25

[Answer question no.1 & any two (2) from the rest]

1. A particle of mass m moves in x-y plane under a potential $V = -\frac{k}{r}$, where k is a constant. Construct the Lagrangian and its equations of motions. 5

2. a. Define Hamiltonian of a system. 2+4+4 =10
   b. Find the Hamiltonian equations of motion for a conservative system.
   c. Obtain the Hamiltonian for a system whose Lagrangian is $L = \left(\frac{1}{2}a\,\dot{x}^2 + \frac{1}{2}b\,\dot{y}^2\right)$.

3. a. Obtain the Lagrangian for a double pendulum vibrating in a vertical plane. 6+4=10
   b. Find the equation of motion for a double pendulum for anyone generalized coordinates.

4. a. The force acting on a particle of m and charge q moving with a velocity $\vec{v}$ in an electric field $\vec{E}$ and magnetic field $\vec{B}$ is given by $\vec{F} = q\,(\vec{E} + \vec{v} \times \vec{B})$. Obtain the Lagrangian defining the motion of such particle. 8+2=10
   b. Find the canonical momentum of the charged particle.

5. a. Find the Hamiltonian of a simple pendulum. 4+6=10
   b. Obtain the Hamiltonian equation of motion of a simple pendulum.

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