REV-01
BSP/08/13

2022/12

**SET A**

# B.Sc. PHYSICS
# FIFTH SEMESTER
# CLASSICAL DYNAMICS
# BSP – 503A

**[USE OMR SHEET FOR OBJECTIVE PART]**

**Duration: 3 hrs.** **Full Marks: 70**

## [ Objective ]

**Time: 30 min.** **Marks: 20**

***Choose the correct answer from the following:*** ***1X20=20***

1. How many independent variables are there in the Lagrangian L=L($q_k, \dot{q}_k, t$), where k=1,2,....N?
   a. N  b. N+1
   c. 2 N  d. 2 N+1

2. A Cyclic coordinate in the Lagrangian L($q_k, \dot{q}_k, t$) corresponds to
   a. $\frac{\partial L}{\partial \dot{q}_k} = 0$  b. $\frac{\partial L}{\partial p_k} = 0$
   c. $\frac{\partial L}{\partial q_k} = 0$  d. $\frac{\partial L}{\partial p_k} = 0$

3. The Lagariangian L($q_k, \dot{q}_k, t$) of a system is defined by
   a. T ($q_k, \dot{q}_k, t$) − V ($q_k$)  b. V ($q_k, \dot{q}_k, t$) − T ($q_k$)
   c. T ($q_k, \dot{q}_k, t$) + V ($q_k$)  d. T ($q_k, t$) − V ($q_k, \dot{q}_k, t$)

4. In a conservative system which one of the following is correct
   a. $\frac{\partial T}{\partial \dot{q}_k} = 0$  b. $\frac{\partial V}{\partial \dot{q}_k} = 0$
   c. $\frac{\partial L}{\partial \dot{q}_k} = 0$  d. $\frac{\partial L}{\partial q_k} = 0$

5. A particle moves in a free space. It's kinetic energy will be
   a. $T = \frac{1}{2} m (\dot{r}^2 + r \dot{\theta}^2 + \dot{z}^2)$  b. $T = \frac{1}{2} m (\dot{r}^2 + r^2 \dot{\theta} + \dot{z}^2)$
   c. $T = \frac{1}{2} m (\dot{r}^2 + r^2 \dot{\theta}^2 + \dot{z}^2)$  d. $T = \frac{1}{2} m (\dot{r}^2 + \dot{\theta}^2 + \dot{z}^2)$

6. The value of the Poisson bracket $[x^2, p]$ will be
   a. $-2x$  b. $2x$
   c. $2p$  d. -2 p

7. Which one of the following is correct for $[L_y, P_z]$
   a. $p_x$  b. $p_y$
   c. $L_x$  d. $L_y$

8. Which one of the following is correct for Hamiltonian equations of motion
   a. $\dot{p}_k = \frac{\partial H}{\partial q_k}$  b. $\dot{q}_k = \frac{\partial H}{\partial p_k}$
   c. $\dot{q}_k = -\frac{\partial H}{\partial p_k}$  d. $\dot{q}_k = \frac{\partial H}{\partial p_k}$

9. Consider two frames S1 and S2, where the later one is moving with a relativistic velocity v along a particular direction. Statements: (i) two events are simultaneous in S1 frame, then (ii) these two events are also simultaneous in S2 frame
   a. Both statements are true  b. Statements (i) is true & (ii) is false
   c. Statements (i) is false & (ii) is true  d. Both statements are false

10. A moving train contracts its length by 80%. Its speed will be
    **a.** 0.8c **b.** 0.6c
    **c.** 0.4c **d.** 0.1c

11. The reduced mass of a system of point masses 2M and 4M will be
    a. 3M/2 **b.** 3M/4
    c. 4M/3 **d.** 6M

12. Two photons moving along the same direction. Their relative velocity will be
    **a.** c/2 **b.** c
    **c.** 2c **d.** c/3

13. The interval between two events will be time-like in Minkowski space-time provided
    **a.** $ds^2 > 0$ **b.** $ds^2 < 0$
    **c.** $ds^2 = 0$ **d.** $ds^2 \leq 0$

14. In null come, a light-like curve makes what angle with the time-axis?
    **a.** $\frac{\pi}{2}$ **b.** $\frac{\pi}{4}$
    **c.** $\frac{\pi}{3}$ **d.** $\frac{\pi}{6}$

15. The electric field in terms of electromagnetic potential will be
    **a.** $\vec{E} = -\vec{\nabla}\varphi - \frac{\partial \vec{A}}{\partial t}$ **b.** $\vec{E} = \vec{\nabla}\varphi - \frac{\partial \vec{A}}{\partial t}$
    **c.** $\vec{E} = -\vec{\nabla}\varphi + \frac{\partial \vec{A}}{\partial t}$ **d.** $\vec{E} = \vec{\nabla}\varphi + \frac{\partial \vec{A}}{\partial t}$

16. The Hamiltonian of a system will defined by
    **a.** $H = \sum p_k \dot{q}_k - L(q_k, \dot{q_k}, t)$ **b.** $H = -\sum p_k \dot{q}_k - L(q_k, \dot{q_k}, t)$
    **c.** $H = L(q_k, \dot{q_k}, t) - \sum p_k \dot{q}_k$ **d.** $H = \sum p_k \dot{q}_k + L(q_k, \dot{q_k}, t)$

17. The relativistic mass-energy relation will be
    a. $E^2 = p^2c^2 + m^2c^4$ **b.** $E^2 = p^2c^4 + m^2c^2$
    c. $E^2 = p^2c^4 + m\,c^2$ **d.** $E = p^2c^2 + m^2c^4$

18. For a conservative force field $\vec{F}$,
    **a.** $\vec{\nabla} \times \vec{F} = 0$ **b.** $\vec{\nabla} \cdot \vec{F} = 0$
    **c.** grad $F$=0 **d.** $\nabla^2 F = 0$

19. A dynamical variable F is a constant of motion if and only if
    **a.** $[F_i, H_j] = \delta_{ij}$ **b.** $[F_i, H_j] = 1$
    **c.** $[F, H] = 0$ **d.** $[F, H] \neq 0$

20. The path a planets revolving around the sun is elliptical. Its total energy will be
    **a.** $E = -\frac{k}{2a}$ **b.** $E = -\frac{2k}{a}$
    **c.** $E = -\frac{k}{a}$ **d.** $E = \frac{k}{2a}$

-- --- --

## Descriptive

Time : 2 hrs. 30 min. Marks : 50

***[ Answer question no.1 & any four (4) from the rest ]***

1. a. A particle moves in a conservative force field with potential V= mgz. Construct the Lagrangian of the system. **4+6=10**

   b. Find the equations of motions using Lagrange's equation.

2. a. A charged particle q moves in an electromagnetic field. What will be its Lagrangian? **2+6+2 =10**

   b. Derive the generalized potential expression.

   c. Write down the Hamiltonian of the system.

3. a. What do you mean by cyclic coordinate? **2+6+2 =10**

   b. Show that generalized momentum corresponding to a cyclic coordinate is conserved.

   c. Define generalized coordinate.

4. a. A particle moves under a central force $F(r) = -\frac{\alpha}{r^2}$. Construct its Lagrangian. **4+3+3 =10**

   b. Construct the Hamiltonian of the system.

   c. Write down the Hamiltonian Equations of motions.

5. a. For a system of two point masses $m_1$ and $m_2$ moves in a plane under a central force. Find the expression of radial and angular acceleration of the system. **6+2+2 =10**

   b. Show that the angular momentum of the system is conserved.

   c. Find an expression of the effective potential energy of the system.

6. a. State Kepler's 1st law of planetary motion. **2+6+2 =10**

   b. Show that path of a two body system under a central force is conic.

   c. State the condition under which the conic section is ellipse and parabola.

7. **a.** Using Lorentz transformation derive velocity addition theorem. **4+2+4 =10**

**b.** Show that the speed of light in vacuum is the upper limit of speed of any object.

**c.** If the proper time measured by a stationary observer is 1 hr, what will be the time interval measured by a moving observe with a relativistic velocity 0.6c.

8. **a.** Prove that four-dimensional volume element dt dx dy dz is invariant under Lorentz transformation. **4+3+3 =10**

**b.** The kinetic energy of a relativistic particle is 2 times its rest mass energy. What will be its speed?

**c.** Show that the volume of a cube as viewed from a reference frame moving with a relativistic velocity v in a direction parallel to one of its edge will be $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ times its original volume.

= = *** = =