REV-01
MSP/08/13

2023/01

SET A

M.Sc. PHYSICS
FIRST SEMESTER
CLASSICAL MECHANICS
MSP – 102 [REPEAT]

[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. The Lagrangian of a charged particle in an electromagnetic field is (where T=kinetic energy, ϕ & A are the magnetic scalar and vector potential respectively)
   - a. L=T+qϕ+q(V.A)
   - b. L=T- qϕ - q(V.A)
   - c. L=T- qϕ+q(V.A)
   - d. L=T+qϕ - q (V.A)
2. The number of degree of freedom of a rigid body in d space-dimensions is
   - a. 2d
   - b. 6
   - c. d(d+1)/
   - d. d
3. If the Lagrangian does not depend on time explicitly, then
   - a. The Hamiltonian is constant
   - b. The Hamiltonian is not constant
   - c. The kinetic energy is constant
   - d. The potential energy is constant
4. If the generating function has the form F=F(q_k,P_k,t) then
   - a. $p_k = \frac{\delta F}{\delta q_k}$ & $Q_k = \frac{\delta F}{\delta P_k}$
   - b. $p_k = -\frac{\delta F}{\delta q_k}$ & $Q_k = \frac{\delta F}{\delta P_k}$
   - c. $p_k = \frac{\delta F}{\delta q_k}$ & $Q_k = \frac{\delta F}{\delta P_k}$
   - d. $p_k = -\frac{\delta F}{\delta q_k}$ & $Q_k = -\frac{\delta F}{\delta P_k}$
5. Principle of Virtual work is analogous to
   - a. Newton's first law
   - b. Newton's Second law
   - c. Newton's third law
   - d. None
6. D' Alembert's principle is analogous to
   - a. Newton's first law
   - b. Newton's second law
   - c. Newton's third law
   - d. None
7. If [F,H]=0 then
   (A). F is a constant of motion
   (B). F does not depend on time explicitly
   - a. Only A
   - b. Only B
   - c. Both A & B
   - d. None
8. In case of a rigid body, having N particles, the number of degrees of freedom is
   - a. Infinity
   - b. N
   - c. 3N
   - d. 3

9. The action and angle variables have the dimensions of
   a. Force and displacement
   b. Angular momentum and angle
   c. Energy and angle
   d. Force and angle

10. The generalised momentum of a charge particle moving in an Electromagnetic field is
   a. P= mv+qA
   b. P= mv-qA
   c. P= mv
   d. None

11. The poisson bracket $[J_x, P_z]$ equals to
   a. P_y
   b. - P_y
   c. 0
   d. None

12. Principle of virtual work is applied to a system of
   a. Dynamic equilibrium
   b. Static equilibrium
   c. Both
   d. None

13. The poisson bracket $[J_x, J_z]$ equals to
   a. J_y
   b. - J_y
   c. 0
   d. J_x

14. Which one of the following is not a fictitious force?
   a. Centripetal force
   b. Coriolis force
   c. Centrifugal force
   d. None of the above

15. Which of the following is the expression for Coriolis force?
   a. $-2m\vec{v}_r \times \vec{\omega}$
   b. $-\vec{\omega} \times (\vec{\omega} \times \vec{R})$
   c. $-\vec{\omega} \times (\vec{R} \times \vec{\omega})$
   d. $-2m\vec{\omega} \times \vec{v}_r$

16. What is the expression for kinetic energy for 1-D oscillators?
   a. $\frac{1}{2} q\, m(q)^2$
   b. $\frac{q^2}{2m(q)}$
   c. $\frac{1}{2} m(q) q^2$
   d. $\frac{m(q)}{2q^2}$

17. Which of the following is the expression for potential energy of a two-coupled pendulum?
   a. $mgl(1-\cos\theta_1) + mgl\cos\theta_2 + \frac{1}{2}k(x_1 - x_2)^2$
   b. $mgl(1-\cos\theta_1) + mgl(1-\cos\theta_2) + \frac{1}{2}k(x_1 - x_2)^2$
   c. $mgl\cos\theta_1) + mgl(1-\cos\theta_2) + \frac{1}{2}k(x_1 - x_2)^2$
   d. $mgl(1-\cos\theta_1) + mgl(1-\cos\theta_2) + \frac{1}{2}k(x_1 - x_2)$

18. Which of the following indicates simple harmonic motion?
   a. $a = x\sin(\omega t + \phi)$
   b. $a = x\sin(\omega\phi + t)$
   c. $x = a\sin(\omega + t\phi)$
   d. $x = a\sin(\omega t + \phi)$

19. How many principal moments of inertia can be defined?
   a. 2
   b. 3
   c. 4
   d. 5

20. Which one of the following is the expression for generalized force?

a. $G_k = -\frac{\partial V}{\partial q_k}$

b. $G_k = \frac{\partial V}{\partial q_k}$

c. $G_k = -\int V \, dq_k$

d. $G_k = \int V \, dq_k$

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Descriptive

Time : 2 hrs. 30mins. **Marks : 50**

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

1. Derive the Hamilton's equations of motion. If the Lagrangian of a harmonic oscillator is given by $L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}kx^2$ then find the equation of motion of the harmonic oscillator. **5+5=10**

2. a. If $[\phi, \psi]$ is the Poission bracket then prove that **5+5=10**

$$\frac{\delta}{\delta t}[\phi, \psi] = \left[\frac{\delta\phi}{\delta t}, \psi\right] + \left[\phi, \frac{\delta\psi}{\delta t}\right]$$

   b. If H is the Hamiltonian and F is any function depending on position, momentum and time then show that

$$\frac{dF}{dt} = \frac{\delta F}{\delta t} + [F,H]$$

3. Show that the transformations are canonical **4+6 =10**
   a. $q = \sqrt{2P}\, sin\, Q$, $p = \sqrt{2P}\, cos\, Q$
   b. $q = P^2 + Q^2$, $p = \frac{1}{2} tan^{-1}(\frac{P}{Q})$

4. a. Obtain the expression for time period of a compound pendulum using Euler- Lagrange equation. **6+4 =10**
   b. Show that [F,[G,H]]+[G,[H,F]]+[H,[F,G]]=0

5. a. Show that the shortest distance between two points in a plane is a straight line. **5+5=10**
   b. Show that for a conservative system the Hamiltonian represents the total energy of the system.

6. a. Find Euler's equations of motion for a rigid body. **6+4 =10**
   b. Obtain the expression for total force on a body for accelerated frame of reference.

7. a. Explain orthogonal transformation. **5+5=10**
   b. Find the equations of motion for a coupled oscillator system.

8. a. Write the simplified equation for potential energy for a coupled pendulum. Write the simplified equation for kinetic energy for a double pendulum system. **3+3+4 =10**
   b. Define chaos. When do we call a differential equation to be non-linear?

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(ii) Show that the computed electric and magnetic fieldssatisfy the Maxwell's first two equations.

(iii) What is the charge density in the present case?

5. a. Event A happens at point ($x_A = 5, y_A = 3, z_A = 0$) and at time t_A given by $ct_A = 15$; event B occurs at (10,8,0) and $ct_B = 5$, both in system S. 2+2+3+2+1=10

(i) What is the invariant interval between A and B?

(ii) Is there an inertial system in which they occur simultaneously? If so, find its velocity (magnitude and direction) relative to S.

(iii) Is there an inertial system in which they occur at the same point? If so, find its velocity relative to S.

b. (i) Write down matrix form of the field tensor $F^{\mu\nu}$. 10

(ii) Write down the Maxwell's equations in terms of the field tensor $F^{\mu\nu}$.

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