REV-01
BSP/13/18

2023/12

SET A

B.Sc. PHYSICS
FIFTH SEMESTER
CLASSICAL DYNAMICS
BSP-503A

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 Hamiltonian H=H(q_k, p_k, t), where k=1,2,....n?
   a. n b. n+1
   c. 2 n d. 2 n+1

2. For a parabolic path of planets, the eccentricity parameter ϵ will
   a. 0 b. 1
   c. >1 d. <1

3. The Lagariangian of a system is $L = m\,\dot{q}^2$, its Hamiltonian will be
   a. $\frac{p^2}{2m}$ b. $\frac{2p^2}{m}$
   c. $\frac{p^2}{4m}$ d. $\frac{p^2}{m}$

4. In a conservative system, the Lagrangian equations of motions will be
   a. $\frac{d}{dt}\left(\frac{\partial T}{\partial q_k}\right) = \frac{\partial T}{d q_k}$ b. $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_k}\right) = \frac{\partial L}{d q_k}$
   c. $\frac{d}{dt}\left(\frac{\partial T}{\partial q_k}\right) = \frac{\partial T}{d \dot{q}_{k_k}}$ d. $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_k}\right) = \frac{\partial l}{d q_k}$

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

6. A central force acting on a particle is given by $F \propto -1/r^2$, potential of the system will be
   a. $V \propto -\frac{1}{r}$ b. $V \propto \frac{1}{r}$
   c. $V \propto -r$ d. $V \propto r$

7. The potential energy of a system is given by $V = mgz$, then the force acting on the particle will be
   a. $\vec{F} = mg\hat{z}$ b. $\vec{F} = -mg\hat{z}$
   c. $\vec{F} = m\,g\,\vec{z}$ d. $\dot{F} = -m\,g\,\dot{z}$

8. Which one of the following is correct for the 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. $q_k = \frac{\partial H}{\partial p_k}$ d. $\dot{q}_k = \frac{\partial H}{\partial \dot{p}_k}$

9. Consider two frames S_1 and S_2, where the later one is moving with a relativistic velocity v along a particular direction. Statements: (i) two events are simultaneous in S_1 frame, then (ii) these two events are not simultaneous in S_2 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 500m long train moving with a speed 0.8c, its moving length will be

a. 200m
b. 250m
c. 300m
d. 500m

11. The reduced mass of positronium atom will be

a. $\frac{m_e}{2}$
b. $\frac{3m_e}{2}$
c. m_e
d. $2m_e$

12. Two photons approaching each other. Their relative velocity will be

a. $c/2$
b. c
c. 2c
d. $c/3$

13. The interval between two events will be light-like in Minkowski space-time provided

a. $ds^2 > 0$
b. $ds^2 < 0$
c. $ds^2 = 0$
d. $ds^2 \leq 0$

14. A moving clock appears

a. slow
b. fast
c. Remain same
d. Sometimes fast and sometimes slow

15. The aerial velocity is defined by

a. $r^2\dot{\theta}$
b. $\frac{1}{2}r^2\dot{\theta}$
c. $\frac{1}{2}r^2\dot{\theta}^2$
d. $r^2\theta^2$

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 energy-momentum relation will be

a. $E = \pm\sqrt{p^2c + m^2c^4}$
b. $E = \pm\sqrt{p^2c^4 + m^2c^2}$
c. $E = \pm\sqrt{p^2c^4 + m\,c^2}$
d. $E = \pm\sqrt{p^2c^2 + m^2c^4}$

18. The total energy of a two-body problem will be

a. $\frac{1}{2}\mu r^2 + \frac{1}{2}\frac{J}{\mu r^2} + V$
b. $\frac{1}{2}\mu r^2 + \frac{1}{2}\frac{J^2}{\mu r^4} + V$
c. $\frac{1}{2}\mu r^2 + \frac{J^2}{\mu r^2} + V$
d. $\frac{1}{2}\mu r^2 + \frac{1}{2}\frac{J^2}{\mu r^2} + V$

19. The angular momentum of two-body problem will be

a. $\dot{\theta} = \frac{J}{\mu r^2}$
b. $J = \frac{\theta}{\mu r^2}$
c. $J = \mu r^2 \dot{\theta}^2$
d. $\dot{\theta} = \mu r^2/J$

The total energy of planets revolving around the sun in a circular paths will be

a. $E = -\frac{\mu k^2}{J^2}$
b. $E = -\frac{\mu k^2}{2J^2}$
c. $E = -\frac{\mu J^2}{k^2}$
d. $E = -\frac{\mu J^2}{2k^2}$

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Descriptive

Time : 2 hrs. 30 mins. Marks : 50

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

1. a. Show that path of planets under a central force motion is conic section. **8+2=10**
   b. State the conditions of parabolic and circular paths of the planets.

2. a. A particles moves in plane under a central potential $V = -\frac{k}{r}$. Find the Lagrangian of the system. **2+6+2 =10**
   b. Obtain the Lagrange's equations of motions.
   c. Find the Hamiltonian of the system.

3. a. Construct the Lagrangian of a simple pendulum. **3+5+2 =10**
   b. Find the Lagrange's equations of motions of a simple pendulum.
   c. For a small oscillation of a simple pendulum, find its time period.

4. a. State Kepler's laws of planetary motions. **4+3+3 =10**
   b. Prove the laws of period of Kepler's law.
   c. If the earth suddenly shrinks to its radius by 25%, calculate the new time period.

5\. a. Derive the components of acceleration of a particle moves in a plane. 5+2+3 =10

b. Show that the angular momentum in a two-body system is conserved.

c. Find an expression of effective potential energy of this two-body system.

6\. a. Define Hamiltonian of a system. 2+4+4 =10

b. Show that the Hamiltonian of a system is $H=\sum p_k \dot{q}_k - L$.

c. Derive the Hamiltonian equations of motions.

7\. a. Using Lorentz transformation relations derive the 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 time interval measured by a moving observer is 3 hrs when moving with a relativistic velocity 0.8c, find its proper time.

8\. a. Using Lorentz transformation relations show that $ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2$ is invariant. 4+3+3 =10

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

c. Derive an expression of time dilation in special relativity theory.

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