2023/06

**SET A**

# M.Sc. PHYSICS
## FIRST SEMESTER
## CLASSICAL MECHANICS
## MSP – 102 [SPECIAL REPEAT]
[USE OMR 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 special Theory of Relativity was given in which year?
   a. 1906 b. 1905
   c. 1907 d. 1908

2. The special relativity proves the existence of
   a. Speed of light in vacuum is constant b. Time is absolute
   c. Ether medium d. Speed of light is variable

3. A double pendulum consist of two point unequal masses $m_1$ and $m_2$, respectively. The KE of the double pendulum is-
   a. $\frac{1}{2}\, m_2\, (\dot{x}_1^2 + \dot{x}_2^2) + \frac{1}{2}\, m_1\, (\dot{y}_1^2 + \dot{y}_2^2)$ b. $\frac{1}{2}\, m_1\, (\dot{x}_1^2 + \dot{x}_2^2) + \frac{1}{2}\, m_2\, (\dot{y}_1^2 + \dot{y}_2^2)$
   c. $\frac{1}{2}\, m_2\, (\dot{x}_1^2 + \dot{y}_1^2) + \frac{1}{2}\, m_1\, (\dot{x}_2^2 + \dot{y}_2^2)$ d. $\frac{1}{2}\, m_1\, (\dot{x}_1^2 + \dot{y}_1^2) + \frac{1}{2}\, m_2\, (\dot{x}_2^2 + \dot{y}_2^2)$

4. Hamiltonian H is in general
   a. $H\,(q, \dot{q}, t)$ b. $H\,(p, \dot{q}, t)$
   c. $H\,(q, \dot{p}, t)$ d. $H\,(q, p, t)$

5. The total number of variables in the Lagrangian $L(\dot{x}, t)$
   a. N+1 b. 2N
   c. N-1 d. 2N+1

6. For a monatomic molecules, the number of degrees of freedom-
   a. 2 b. 3
   c. 4 d. 5

7. Two point masses $m_1$ and $m_2$ are connected by a mass-less string hanging over a smooth pulley (Atwood Machine). The equation of motions-
   a. $\ddot{x} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$ b. $\ddot{x} = \left(\frac{m_1}{m_1 + m_2}\right) g$
   c. $\ddot{x} = \left(\frac{-m_2}{m_1 + m_2}\right) g$ d. $\ddot{x} = \left(\frac{2\, m_1\, m_2}{m_1 + m_2}\right) g$

8. If the poisson bracket $\{x, p\} = 1$, then the poisson bracket $\{x^2, p\}$ is?
   a. $2x$ b. 2p
   c. 1 d. 0

9. Hamilton's canonical equations of motion for a conservative system are

a. $\dot{q}_i = \frac{\partial H}{\partial p_i}, \dot{p}_i = \frac{\partial H}{\partial q_i}$

b. $\dot{q}_i = -\frac{\partial H}{\partial p_i}, \dot{p}_i = -\frac{\partial H}{\partial q_i}$

c. $\dot{q}_i = -\frac{\partial H}{\partial p_i}, \dot{p}_i = \frac{\partial H}{\partial q_i}$

d. $\dot{q}_i = \frac{\partial H}{\partial p_i}, \dot{p}_i = -\frac{\partial H}{\partial q_i}$

10. A constant force F is applied on a relativistic scalar particle of mass m. If the particle is at rest at t=0, then the velocity at any instant will be

a. $\frac{F t}{\sqrt{F^2 t^2 + m^2 c^2}}$

b. $\frac{F c t}{\sqrt{F^2 t^2 + m^2 c^2}}$

c. $\frac{F c t}{\sqrt{F^2 c^2 t^2 + m^2}}$

d. $\frac{F t}{\sqrt{F^2 + m^2 c^2}}$

11. The angular momentum in two body problem is

a. $p_\theta = \mu r \dot{\theta}$

b. $p_\theta = \mu r \dot{\theta}^2$

c. $p_\theta = \mu r^2 \dot{\theta}$

d. $p_\theta = \mu r^2 / \dot{\theta}$

12. If a dynamical variable F is explicitly independent of time t, then the variable satisfies

a. $\{H, F\} = \frac{dF}{dt}$

b. $\{H, F\} = -\frac{dF}{dt}$

c. $\{F, H\} = 1$

d. $\{F, H\} = 0$

13. A charge particle q is moving in an electromagnetic field with a velocity $\vec{v}$. The generalized potential U is-

a. $q\Phi - \frac{q}{c}(\vec{A} \circ \vec{v})$

b. $\frac{1}{2m}\left[q\Phi - \frac{q}{c}(\vec{A} \circ \vec{v})\right]$

c. $\frac{1}{2m} q\Phi$

d. $q\Phi$

14. Two photon approach each other. Their relative velocity will be

a. 0

b. c

c. 2c

d. -c

15. The Lagrange's equations of motion are second degree, then the degree's of freedom will be?

a. 2N+1

b. N

c. 2N-1

d. N+1

16. The generalized coordinate $q_k$ of a classical system with Lagrangian L is said to be cyclic if

a. $\frac{\partial L}{\partial q_k} = \dot{q}_k$

b. $\frac{\partial L}{\partial \dot{q}_k} = 0$

c. $\frac{\partial L}{\partial q_k} = \frac{\partial}{\partial t}(\frac{\partial L}{\partial \dot{q}_k})$

d. $\frac{\partial L}{\partial q_k}$=0

17. The kinetic energy of a particle moving in free space is

a. $T = \frac{1}{2} m (\dot{r}^2 + r^2\dot{\theta}^2 + \dot{z}^2)$

b. $T = \frac{1}{2} m(\dot{r}^2 + r^2 + \dot{z}^2)$

c. $T = \frac{1}{2} m (\dot{r}^2 + \dot{\theta}^2 + \dot{z}^2)$

d. $T = \frac{1}{2} m(r^2\dot{\theta}^2 + \dot{z}^2)$

18. The rocket ship contracted to its length by 99%.Its velocity will be

a. $0.1c$

b. $0.2c$

c. $0.3c$

d. $0.9c$

19. The Hamiltonian H is in general

a. $H(q, p, t)$ b. $H(q, \dot{q}, t)$

c. $H(\dot{q}, p, t)$ d. $H(p, t)$

20. The value of the bracket $\{A, \{B, C\}\} + \{B, \{C, A\}\} + \{C, \{A, B\}\}$

a. 0 b. 1

c. -1 d. 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 Lagrangian for a particular system 8+2=10

$$L = \frac{m}{2}(a\dot{x}^2 + 2b\dot{x}\dot{y} + c\dot{y}^2) - \frac{K}{2}(ax^2 + 2bxy + cy^2),$$

where $a, b, c$ are arbitrary constants?

(a) What are the equations of motion for x-coordinate?

(b) Examine the cases $a = b = c$

2. Show that Poisson bracket $\{A, \{B, C\}\} + \{B, \{C, A\}\} + \{C, A, B\} = 0$. 10

3. Write down the Lorentz transformation relations for inertial frame of reference. Using this transformation show that $ds^2 = -dt^2 + dx^2 + dy^2 + dz^2$ is invariant. 10

4. Show that the following transformations are canonical. 5+5=10

(a) $P = \frac{1}{2}(p^2 + q^2),\ Q = \tan^{-1}\left(\frac{q}{p}\right)$

(b) $P = q\cot p,\ Q = \log\left(\frac{1}{q}\sin p\right)$

5. (a) What are the postulates of Special Relativity? 4+6=10
(b) Using special theory of relativity, derive the relativistic energy relation $E^2 = p^2c^2 + M_0^2c^4$ where symbols have their usual meanings.

6. Construct the Lagrangian of a simple pendulum. Find the equations of motions and its time-period. 10

7. Using Hamilton-Jacobi equation derive Kepler's Law of orbit. 10

8. Two small blocks, each of mass $M$, attached to two identical springs of spring constant k/2. One of the springs is attached to a wall and other with block. The masses slide along the surface and the friction is negligible. Find the frequency of normal modes of the system. 10

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