OMR Answer Sheet No.

Question Booklet Number

7078

M.Sc. (Semester-Ist) Examination, 2022-23

Booklet Series

A

PHYSICS

Classical Mechanics

[Time : 1 : 30 Hours

[समय : 1 : 30 घण्टे

[Maximum Marks : 75

[अधिकतम अंक : 75

(To be filled in by the Candidate / निम्न पूर्तियाँ परीक्षार्थी स्वयं भरें)

Roll No. (in figures) ______________________

अनुक्रमांक (अंकों में)

Roll No. (in words) ______________________

अनुक्रमांक (शब्दों में)

Enrolment No. (in figures) ______________________

Name of College ______________________

कॉलेज का नाम

Signature of Invigilator

कक्ष निरीक्षक के हस्ताक्षर

Instructions to the Examinee :

1. Do not open the booklet unless you are asked to do so.
2. The booklet contains 75 questions. Examinee is required to answer any 50 questions in the OMR Answer-Sheet provided and not in the question booklet. In case Examinee attempts more than 50 Questions, ***first*** 50 attempted questions will be evaluated. All Questions carry equal marks.
3. Examine the Booklet and the OMR Answer-Sheet very carefully before you proceed. Faulty question booklet due to missing or duplicate pages/questions or having any other discrepancy should be immediately replaced.

(Remaining Instructions on last page)

परीक्षार्थियों के लिए निर्देश :

1. प्रश्न-पुस्तिका को तब तक न खोलें जब तक आपसे कहा न जाए।
2. प्रश्न-पुस्तिका में 75 प्रश्न हैं। परीक्षार्थी को किन्हीं 50 प्रश्नों को दी गई OMR उत्तर-पत्रक पर ही हल करना है। परीक्षार्थी द्वारा 50 से अधिक प्रश्नों को हल करने की स्थिति में, **प्रथम** 50 उत्तरों को ही मूल्यांकित किया जाएगा। सभी प्रश्नों के अंक समान हैं।
3. प्रश्नों के उत्तर अंकित करने से पूर्व प्रश्न-पुस्तिका तथा OMR उत्तर-पत्रक को सावधानीपूर्वक देख लें। दोषपूर्ण प्रश्न-पुस्तिका, जिसमें कुछ भाग छपने से छूट गये हों या प्रश्न एक से अधिक बार छप गये हों या किसी भी प्रकार की कमी हो, उसे तुरन्त बदल लें।

(शेष निर्देश अन्तिम पृष्ठ पर)

1. Constraint in a rigid body is:

(A) Non-holonomic

(B) Scleronomic

(C) Rheonomic

(D) Unilateral

2. A particle is constrained to more along the inner surface of a fixed hemispherical bowl the number of degree of freedom of the particle is

(A) One

(B) Two

(C) Three

(D) Four

3. D' Alembert's principle is,

(A) $\Sigma(F_i - p_i).\ \delta r_i = 0$

(B) $\Sigma(F_i - p_i).\delta r_i = 0$

(C) $\Sigma(F_i + p_i).\ \delta r_i = 0$

(D) $\Sigma(F_i + p_i).\delta r_i = 0$

4. Under canonical transformations, the fundamental Poission brackets are

(A) Zero

(B) -1

(C) +1

(D) invariant

5. The potential energy of a conservative system is independent of:

(A) Generalised coordinates

(B) Force

(C) Generalised velocity

(D) None of these

6. Lagrangian of particle is $L = \frac{1}{2} m\dot{q}^2 - \frac{\lambda}{2} q\dot{q}^2$, where m is the mass, q is generalise coordinate and λ is a constant. The Hamiltonian for the system is given by;

(A) $\frac{p^2}{2m} + \frac{\lambda q p^2}{2m^2}$

(B) $\frac{pq}{2}$

(C) $\frac{p^2}{2(m-\lambda q)}$

(D) $\frac{p^2}{2(m+\lambda q)}$

7. A linear transformation of a generalised coordinate q and the corresponding momentum p to Q & p given by Q=q+p; p=q+α p is canonical if the value of the constant α is

(A) -1

(B) +1

(C) 0

(D) +2

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

(A) $\frac{2(1+\dot{q})}{q^3}$

(B) $\frac{2(1-\dot{q})}{q^3}$

(C) $\frac{2}{q^3}$

(D) $\frac{\dot{q}}{q^3}$

9. A particle is moving on elliptical path under inverse square law force of the form $F(r) = -\frac{k}{r^2}$. The ecentricity of the orbit is

(A) a function of total energy and angular momentum

(B) independent of total energy

(C) independent of angular momentum

(D) nothing can be said

10. The virial theorm is

(A) $T + \bar{V} = \text{constant}$

(B) $\bar{T} = \sum_i \overline{F_i r_i}$

(C) $\bar{T} = \frac{1}{2}\sum_i \overline{F_i r_i}$

(D) $\bar{T} = -\frac{1}{2}\sum_i \overline{F_i r_i}$

11. The Lagrangian for a charged particle moving in an electromagnetic field is:

(A) $L = T + q\varphi - q(\vec{v}.\vec{A})$

(B) $L = T - q\varphi - q(\vec{v}.\vec{A})$

(C) $L = T - q\varphi + q(\vec{v}.\vec{A})$

(D) $L = T + q\varphi + q(\vec{v}.\vec{A})$

12. The reduced mass of two particles of masses m_1 & m_2 is

(A) $m_1 - m_2$

(B) $\frac{m_1 + m_2}{2}$

(C) $\frac{m_1 m_2}{m_1 + m_2}$

(D) $\frac{m_1 + m_2}{m_1 m_2}$

13. According to the principle of least action

(A) $\Delta\int\left(\sum_i p_i \dot{q}_i - H\right)dt = 0$

(B) $\Delta\int (H - L)dt = 0$

(C) $\Delta\int \sum_i p_i \dot{q}_i \, dt = 0$

(D) $\int \sum_i p_i \dot{q}_i \, dt = 0$

14. Degrees of freedom for a N-particles system with k constraints is:

(A) $f = 3N - k$

(B) $f = 3N + k$

(C) $f = 2N - k$

(D) $f = 2N + k$

15. Consider a comet of mass m moving in an elliptical orbit around the sun. Which one of the following is true;

(A) The linear momentum of the comet is a constant.

(B) The kinetic energy of the comet is constant

(C) The acceleration of the comet is maximum when it closest to the sun

(D) The acceleration of the comet is maximum when it is farthest to the sun

16. The condition of Canonical transformation is

(A) PQ=pq

(B) p=q, Q=P

(C) PdQ −pdq is an exact differential

(D) PQ − pq = PQ+pq

17. A particle of mass m moves under the action of central force whose potential is

$V(r) = km\, r^3$. Considering the circular motion of the particle, the kinetic energy of the particle is;

(A) $\frac{3}{2} kmr^3$

(B) $\frac{2}{3} kmr^3$

(C) $\frac{3}{2} kmr^2$

(D) $\frac{2}{5} kmr^2$

18. The Hamiltonian of a particle is $H = \frac{p^2}{2m} + pq$, where q is generalised coordinate & p is the corresponding canonical momentum. The Lagrangian is

(A) $\frac{m}{2}\left(\frac{dq}{dt} + q\right)^2$

(B) $\frac{m}{2}\left(\frac{dq}{dt} - q\right)^2$

(C) $\frac{m}{2}\left[\left(\frac{dq}{dt}\right)^2 + q\frac{dq}{dt} - q^2\right]$

(D) $\frac{m}{2}\left[\left(\frac{dq}{dt}\right)^2 - q\frac{dq}{dt} + q^2\right]$

19. A particle is moving under central force of field, than the correct statement related;

(A) The motion of the particle is always on a circular path

(B) Its kinetic energy is a constant

(C) Its angular momentum is a constant

(D) Its linear momentum is a constant

20. Total linear momentum of a system of particles about the centre of mass is:

(A) 1

(B) -1

(C) 0

(D) ∞

21. The degrees of freedom of a rigid body moving in a three dimensional space is:

(A) 1

(B) 3

(C) 6

(D) 9

22. Generalised potential (potential related to non-conservative system) is a function of:

(A) Generalised coordinate only

(B) Generalised velocity only

(C) Both generalised coordinate and generalised velocity

(D) None of these

23. The work done by a conservative force for any closed path is:

(A) Positive

(B) Negative

(C) Zero

(D) Infinite

24. The degrees of freedom of four particles moving freely in a plane is:

(A) 12

(B) 8

(C) 6

(D) 1

25. Lagrangian for a simple pendulum with rigid support (considering the equilibrium position of bob as reference point) is:

(A) $\frac{1}{2}ml^2\dot{\theta}^2 - mgl\cos\theta$

(B) $\frac{1}{2}ml^2\dot{\theta}^2 + mgl\cos\theta$

(C) $\frac{1}{2}ml^2\dot{\theta}^2 - mgl(1+\cos\theta)$

(D) $\frac{1}{2}ml^2\dot{\theta}^2 - mgl(1-\cos\theta)$

26. The Lagranges equation for LC circuit is:

(A) $Lq' - \frac{q}{c} = 0$

(B) $Lq' + \frac{q}{c} = 0$

(C) $Lq' + \frac{q}{c} = 0$

(D) $Lq' - \frac{q}{c} = 0$

27. The Lagrangian L is defined as:

(A) $L = T - V$

(B) $L = T + V$

(C) $L = 2T - V$

(D) $L = 2T + V$

28. The Lagrangian equation for a conservative system is:

(A) $\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_j}\right) - \frac{\partial T}{\partial q_j} = 0$

(B) $\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_j}\right) + \frac{\partial T}{\partial q_j} = 0$

(C) $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_j}\right) - \frac{\partial L}{\partial q_j} = 0$

(D) $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_j}\right) + \frac{\partial L}{\partial q_j} = 0$

29. If Lagrangian L of a system does not contain time t explicitly, then the Hamiltonian H of the system is:

(A) Zero

(B) Constant

(C) Variable

(D) None of these

30. A satellite has its largest and smallest orbital speed are given by v_{max} and v_{min} respectively. The eccentricity of the orbit of the satellite is:

(A) $\frac{v_{max} - v_{min}}{v_{max} + v_{min}}$

(B) $\frac{v_{max} + v_{min}}{v_{max} - v_{min}}$

(C) $\frac{v_{max} - v_{min}}{v_{max} - v_{min}}$

(D) $\frac{v_{max} + v_{min}}{v_{max} + v_{min}}$

31. The total energy of a planet is negative, the nature of the orbit is a:

(A) Ellipse

(B) Hyperbola

(C) Parabola

(D) Circle

32. Which of the following relation is correct for a planet revolving around the sun;

(A) $T \propto a^3$

(B) $T \propto a^2$

(C) $T^3 \propto a^2$

(D) $T^2 \propto a^3$

(where the terms have usual meaning)

33. A planet is revolving around the sun in an elliptical orbit. The total energy of the planet depends on;

(A) Semi minor axis

(B) Semi major axis

(C) Independent of axis

(D) Both (A) & (B)

34. Lagrangian for the Kepler's problem is given by

$L = \frac{1}{2}(\dot{r}^2 + r^2\dot{\theta}^2) + \frac{\mu}{r} (\mu > 0)$

Where (r, θ) denotes the polar coordinates and the mass of the particle is unity, then

(A) $P_\theta = 2r^2\dot{\theta}$

(B) $P_r = 2r$

(C) The angular momentum of the particle is a constant

(D) The total energy of the particle is time dependent

35. A particle of mass m is constrained to move on the plane curve xy = c (c>0) under the gravity (y axis is vertical). The lagrangian of the particle is

(A) $\frac{1}{2} m \dot{x}^2 \left(1 + \frac{c^2}{x^4}\right) + \frac{mgc}{x}$

(B) $\frac{1}{2} m \dot{x}^2 \left(1 + \frac{c^2}{x^4}\right) - \frac{mgc}{x}$

(C) $\frac{1}{2} m \dot{x}^2 \left(1 + \frac{c}{x^2}\right) + \frac{mgc}{x}$

(D) $\frac{1}{2} m \dot{x}^2 \left(1 + \frac{c}{x^2}\right) - \frac{mgc}{x}$

36. A satellite is moving in a circular orbit around the earth. If T, V, E are average kinetic energy, average potential energy, total energies respectively. Then which one of the following option is correct?

(A) V = −2T

E = 0

(B) V = −T/2

E = −T/2

(C) V = −2T

E = −T

(D) V =−3/2T

E = −T/2

37. If $L = \frac{1}{2} ml^2 (\theta^2 + Sin^2\theta \varphi 2)$ + mgl cosθ, where m, l and g are constant. Which of the following is conserved

(A) $\frac{\varphi}{\sin\theta}$

(B) $\varphi \sin\theta$

(C) $\varphi Sin^2\theta$

(D) $\frac{\varphi}{\sin^2\theta}$

38. The Lagrangian of a particle moving is given by $L = \frac{1}{2} m(\dot{r}^2 + r^2\dot{\theta}^2) - V(r)$. The generalised momentum correspond to θ is given by,

(A) $mr^2\dot{\theta}$

(B) $mr\dot{\theta}$

(C) $mr^2\dot{\theta}^2$

(D) $mr\dot{\theta}^2$

39. If the generalised coordinate q_k is cyclic to Lagrangian L then:

(A) $\frac{\partial L}{\partial q_k} = 1$

(B) $\frac{\partial L}{\partial q_k} = 0$

(C) $\frac{\partial L}{\partial q_k} = -1$

(D) $\frac{\partial L}{\partial q_k}$ = costant

40. Mathematically the Hamiltonian H of a system is defined as:

(A) $H = \sum P_i \dot{q}_i - L$

(B) $H = \sum \dot{q}_i p_i - L$

(C) $H = \sum P_i \dot{q}_i + L$

(D) $H = \sum \dot{q}_i p_i + L$

41. For a conservative system the Hamiltonian H is:

(A) H = T − V

(B) H = V − T

(C) H = T + V

(D) H = 0

(If the transformation equation is not a function of time t)

42. The Hamilton's principle is given by;

(A) $\delta \int_{t_1}^{t_2} L\,dt = 0$

(B) $\Delta \int_{t_1}^{t_2} L\,dt = 0$

(C) $\delta \int_{t_1}^{t_2} H\,dt = 0$

(D) $\Delta \int_{t_1}^{t_2} H\,dt = 0$

43. Hamilton canonical equation of motion for a conservative system are (q_k, p_k, H are generalised coordinate, generalised momentum, Hamiltonian respectively)

(A) $-\frac{dq_k}{dt} = \frac{\partial H}{\partial p_k}$ and $\frac{dp_k}{dt} = \frac{\partial H}{\partial q_k}$

(B) $\frac{dp_k}{dt} = \frac{\partial H}{\partial p_k}$ and $\frac{dq_k}{dt} = \frac{\partial H}{\partial q_k}$

(C) $\frac{dq_k}{dt} = \frac{\partial H}{\partial p_k}$ and $\frac{dp_k}{dt} = \frac{\partial H}{\partial q_k}$

(D) $\frac{dq_k}{dt} = \frac{\partial H}{\partial p_k}$ and $-\frac{dp_k}{dt} = \frac{\partial H}{\partial q_k}$

44. Poisson bracket of $[q_i, q_j]$ with respect to canonical variables (q, p) is;

(A) 1

(B) -1

(C) 0

(D) δ_{ij}

45. Rutherford scattering cross section;

(A) has the dimensions of solid angle

(B) has the dimensions of area

(C) has the dimensions of angle

(D) has no dimension

46. Rutherford scattering cross section is proportional to; (E stands for energy)

(A) E^2

(B) $\frac{1}{E^2}$

(C) E

(D) $\frac{1}{E}$

47. Choose the correct statement;

(A) δ-variation involve time

(B) Δ - variation does not involve time

(C) In Δ - variation time as well as position coordinates are allowed to vary

(D) In δ - variation time as well as position coordinates are allowed to vary

48. If a function F does not depend on time explicitly, than its Poisson's bracket with hamiltonian H is;

(A) [F, H] = 0

(B) [F, H] = 1

(C) [F, H] = -1

(D) None of these

49. The component of generalised force in terms of generalised potential U is

(A) $-\frac{\partial U}{\partial q_i} + \frac{d}{dt}\left(\frac{\partial U}{\partial q_i}\right)$

(B) $\frac{\partial U}{\partial q_i} - \frac{d}{dt}\left(\frac{\partial U}{\partial q_i}\right)$

(C) $\frac{\partial U}{\partial q_i} - \frac{d}{dt}\left(\frac{\partial U}{\partial q_i}\right)$

(D) $-\frac{\partial U}{\partial \dot{q}_i} + \frac{d}{dt}\left(\frac{\partial U}{\partial q_i}\right)$

50. Total virtual work done on N.particle system is

(A) Zero

(B) Maximum

(C) Minimum

(D) None

51. The Lagrangian for a system is

$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2 + \dot{z}^2)$ -mgy

The cyclic coordinates are

(A) x & z

(B) y & z

(C) x, y

(D) z only

52. Generalised coordinates

(A) depend on each other

(B) are independent of each other

(C) are necessarily spherical coordinate

(D) None

53. The conditions which restrict the motion of the system are called

(A) Constraints

(B) Degree of freedom

(C) Generalized coordinate

(D) None

54. Eccentricity greater than 1, the orbit nature is

(A) Parabola

(B) Hyperbola

(C) Ellipse

(D) Circle

55. The energy of the bound orbit is

(A) +ve

(B) −ve

(C) Zero

(D) Infinity

56. In quantum mechanics, Poisson brackets are similar to the

(A) Commutator brackets

(B) Square brackets

(C) Phase brackets

(D) None of these

57. From the given transformation

$q = \sqrt{2P}\sin\theta$ and $p = \sqrt{2P}\cos\theta$, we have

(A) $\tan\theta = \frac{q}{p}$

(B) $\cot\theta = \frac{p}{q}$

(C) $\sec\theta = \frac{q}{p}$

(D) Both (A) and (B)

58. The Poisson bracket of $[L_y, L_z]$=

(A) L_x

(B) L_y

(C) L_z

(D) None of these

59. There is inverse relation between Poisson brackets and ______

(A) Lagranges bracket

(B) Jacobi's bracket

(C) Commutators

(D) Operators

60. The kinetic energy of a simple pendulum of length l in terms of generalised coordinate θ is given by

(A) $T = \frac{1}{2}mv^2$

(B) $T = \frac{1}{2}ml^2\dot{\theta}^2$

(C) $T = ml^2\theta^2$

(D) $T = \frac{1}{2}ml^2\theta^2$

61. The potential energy of the oscillating system will be

(A) $\frac{1}{2}kx^2$

(B) mgh

(C) 0

(D) $-\frac{1}{2}kx^2$

62. The space involved in Hamilton's system is called ________

(A) Configuration space

(B) Phase space

(C) Both (A) and (B)

(D) None of these

63. Reduced mass of molecule "CO" is

(A) 1.15×10^{-26} kg

(B) 1.62×10^{-27} kg

(C) 1.15×10^{-36} kg

(D) 1.62×10^{-37} kg

Given - 1 amu=1.67×10^{-27} kg

64. In Rutherford's experiment 10^5 α-particles are scattered at an angle of 2^0, calculate the number of α-particles scattered at an angle of 20^0.

(A) 5

(B) 15

(C) 10

(D) 20

65. The modified Hamilton's principle is given by:

(A) $\delta\sum_j\int_{t_1}^{t_2} p_j dq_j - \delta\int_{t_1}^{t_2} H dq_j = 0$

(B) $\delta\sum_j\int_{t_1}^{t_2} p_j dq_j + \delta\int_{t_1}^{t_2} H dq_j = 0$

(C) $\delta\sum_j\int_{t_1}^{t_2} p_j dq_j + \int_{t_1}^{t_2} H dt = 0$

(D) $\delta\sum_j\int_{t_1}^{t_2} p_j dq_j - \delta\int_{t_1}^{t_2} H dt = 0$

66. In case of canonical transformations:

(A) The form of the Hamilton's equations is preserved

(B) The form of the Hamilton's equations can not be preserved

(C) The form of the Hamilton's equations may or may not be preserved

(D) None of the above

67. The equation of motion for one dimensional harmonic oscillator is

(A) $m\frac{d\dot{y}}{dt} + ky = 0$

(B) $m\frac{d^2\dot{y}}{dt^2} + ky = 0$

(C) $m\frac{d^2\ddot{a}}{dt^2} + ky = 0$

(D) $m\frac{d^2\dot{j}}{dt^2} + ky = 0$

68. The homogeneity of time leads to the law of conservation of:

(A) energy

(B) linear momentum

(C) angular momentum

(D) parity

69. If the generalized coordinate is angle θ, the corresponding generalized force has the dimensions of:

(A) torque

(B) force

(C) momentum

(D) energy

70. The generalized momentum P_x of a particle of mass m with velocity v_x in an electromagnetic field is given by:

(A) $P_x = mv_x + qA_x$

(B) $P_x = mv_x - qA_x$

(C) $P_x = mv_x$

(D) $P_x = qv_x A_x$

71. The Hamiltonian corresponding to the Langrangian $L = a\dot{x}^2 + b\dot{y}^2 - kxy$ is

(A) $\frac{P_x^2}{2a} + \frac{P_y^2}{2b} + kxy$

(B) $\frac{P_x^2}{4a} + \frac{P_y^2}{4b} + kxy$

(C) $\frac{P_x^2 + P_y^2}{4ab} + kxy$

(D) $\frac{P_x^2}{4a} + \frac{P_y^2}{4b} - kxy$

72. Mutual interaction forces between two particles can change:

(A) The kinetic energy but not the linear momentum

(B) The linear momentum but not the kinetic energy

(C) The linear momentum as well as kinetic energy

(D) Neither the linear momentum nor the kinetic energy

73. The product of generalised coordinate and its conjugate momentum has the dimensions of :

(A) angular momentum

(B) linear momentum

(C) Force

(D) Energy

74. Hamilton's canonical equations in terms of Poisson's bracket are:

(A) $\dot{q}_i = [q_i, H], \dot{p}_i = [p_i, H]$

(B) $\dot{q}_i = [H, q_i], \dot{p}_i = [H, p_i]$

(C) $\dot{q}_i = [p_i, H], \dot{p}_i = [q_i, H]$

(D) $\dot{q}_i = [H, p_i], \dot{p}_i = [H, q_i]$

75. The dimensions of generalized momentum:

(A) May be those of angular momentum

(B) May be those of linear momentum

(C) Only (A)

(D) Both (A) & (B)