Mechanics

Mechanics—It is a branch of physics which deals with physical objects in motion and at rest under the influence of external and internal interaction.

Classical Mechanics—The mechanics based on Newton's laws of motion and alternatively developed by Lagrange, Hamilton and others. Semi permeable dipole moment, enthalpy, toluene internal enthalpy of vaporisation, sublimation.

1. **Newtonian (vectorial) Mechanics**—Classical mechanics deals with the Newton's laws and their consequences. Here vector quantities such as force, acceleration, momentum etc. are used.
2. **Analytical Mechancis**—It is an alternative and superior schemes in classical mechanics, developed by D' Alembert, Lagrange, Hamilton and others. Here scalar quantities such as energy rather than vector quantities are used and dynamical relations are obtained by systematic process of differentiation.

Co-ordinate Systems

Two dimensional systems :

1. Cartesian co-ordinate system (x, y)
2. Polar co-ordinate system (r, θ)
3. Relation between cartesian and polar co-ordinate systems.

$$\begin{cases} x = r\cos\theta \\ y = r\sin\theta \end{cases}$$

and $$r = \sqrt{x^2 + y^2}, \quad \theta = \tan^{-1} y/x$$

Three dimensional systems :

1. Cartesian co-ordinate system (x, y, z)
2. Cylindrical co-ordinate system (r, θ, z)
3. Spherical coordinate system (r, θ, ϕ)
4. Relation between cartesian and cylindrical co-ordinate systems

$$\begin{cases} x = r\cos\theta \\ y = r\sin\theta \\ z = z \end{cases} \quad \text{and} \quad \begin{cases} r = \sqrt{x^2 + y^2 + z^2} \\ \theta = \tan^{-1} y/x \\ z = z \end{cases}$$

5. Relation between cartesian and spherical co-ordinae systems.

$$\begin{cases} x = r\sin\theta\cos\phi \\ y = r\sin\theta\sin\phi \\ z = r\cos\theta \end{cases} \quad \text{and} \quad \begin{cases} r = \sqrt{x^2 + y^2 + z^2} \\ \theta = \tan^{-1}\left(\sqrt{\dfrac{x^2 + y^2}{z}}\right) \\ \phi = \tan^{-1} y/x \end{cases}$$

Frame of Reference

Point and event—If the physical phenomena occur in a space, its position is known as a point, the time of occurrence and the point taken together are called an event.

Frame of Reference—If a co-ordinate system is attached to a rigid body and one describe the position of any particle relative to it, then such co-ordinate system is called frame of reference.

Space-time reference system—The event which is represented by a position (point) and time is referred as space-time reference system.

Newton's Laws of Motion

1. **Law of inertia (First law)**—A body continues in its state of rest or uniform motion, unless no external force is applied to it.
2. **Law of force (Second law)**—The time rate of change of momentum is proportional to impressed force.

$$F = \frac{dP}{dt} = ma.$$

where P is momentum, m is mass and a an acceleration.

3. **Law of action and reaction (Third law)**—For every action, there is always equal and opposite reaction.

$$F_{ij} = -F_{ji}$$

Inertial frames (Galilean frames of reference)—A frame of reference in which law of inertia holds.

1. All those frames, which are moving with constant velocity relative to an initial frame are also inertial.

2. An inertial frame is non-accelerated.

   Non-inertial frames : an accelerated frame of reference.

Mechanics of a Particle

1. **Conservation of linear momentum**—In absence of external force, linear momentum of a particle is conserved.

   i.e. $$\frac{dP}{dt} = 0$$

   $$\Rightarrow \quad P = mv = \text{constant}$$

   here v is the velocity of a particle.

2. **Conservation of angular momentum**—In absence of external torque, angular momentum of a particle is constant of motion.

   $$\tau = \frac{dJ}{dt} = 0$$

   $$\Rightarrow \quad J = \text{constant}$$

Conservation of Energy

1. **Work energy theorem**—If W_{12} is the work done by an external force F upon a particle in displacing from point 1 to 2 and the change in kinetic energy from point 1 to 2 is T_1 and T_2 respectively, then

   $$W_{12} = \int_1^2 F.dr = T_2 - T_1$$

   where $$T_i = \frac{1}{2} mv_i^2$$

   ($i = 1, 2$) is kinetic energy

2. **Conservative force**—If the force is conservative, the work done on the particle around a closed path in the force field is zero.

   $$\oint F.dr = 0$$

3. **Work and potential energy**—If W_{12} is the work done by an external force F upon a particle in displacing from point 1 to 2 and the change in potential energy from point 1 to 2 is V_1 and V_2 respectively, then

   $$W_{12} = \int_1^2 F.dr = V_1 - V_2$$

   where $$V(r) = -\int_\infty^r F.dr$$

4. **Energy Conservation law**—The sum of kientic energy and potential energy (*i.e.*, total mechanical energy) of a particle remains constant in a conservative force field.

Mechanics of System of Particles

1. **External and internal forces**—If a mechanical system consists of N (N > 1) particles, then the force on the i-th particle is

   $$F_i = F_i^e + \sum_{j=1}^{N} F_{ij}$$

   where F_i^e is the external force acting on i-th particle due to sources outside the system and F_{ij} is the internal force on i-th particle due to j-th particle.

2. **Centre of mass**—The centre of mass is

   $$R = \frac{\sum_i m_i r_i}{\sum_i m_i} = \frac{\sum_i m_i r_i}{M}$$

   where $\sum_i m_i = M$ (total mass of system)

3. **Conservation of linear momentum**—If the total external force F^e on the system is zero, the total linear momentum is constant of motion.

   $$P = \sum_i m_i v_i = \text{constant}$$

4. **Centre of mass-frame of reference**—In centre of mass-frame of reference total linear momentum is zero.

   $$P = \sum_i m_i v_i = 0$$

5. **Conservation of total angular momentum**—The total angular momentum of a system of particles is conserved.

   $$\Sigma J_i = \text{constant}$$

6. **Relation between angular momentum (J) and angular momentum about centre of mass Jcm**—The total angular momentum of a system of particles about a point is the angular momentum of the system about the centre of mass plus the angular momentum about the reference point of the system mass concentrated at the centre of the mass.

Dynamical System

Dynamical System—It's a system of particles.

Configuration—The set of positions of all the particles.

Degree of Freedom—The minimum number of independent coordinates (or variables) required to specify the system.

Constraints—Limitations imposed on the motion of a system.

1. **Holonomic Constraints**—If the constraints can be expressed as equation form then holonomic constraints otherwise non-holonomic constraints.
2. **Rheonomous and Scleronomous Constraints**—Equation of constraints containing time as explicit variable then rheonomous otherwise scleronomous constraints.
3. **Conservative and Dissipative Constraints**—In conservative constraints total mechanical energy of the system is conserved during constrained motion and constraint forces do not do any work otherwise dissipative constraints.

Forces of Constraints—Constraints are always related to force which restrict the motion of the system. These forces are called forces of constraints.

Generalized Coordinates—A set of independent coordinates sufficient in number to describe completely the state of configuration of a dynamical system. These coordinates are denoted as $q_1, q_2, \ldots\ldots q_n$.

Principle of Virtual Work—The work done is zero in the case of an arbitrary displacement of a system from a position of equilibrium

$$\delta W = \sum_{i=1}^{N} F_i \cdot \delta r_i = 0$$

where F_i is the total of force on i-th particle and δr_i is the virtual displacement.

D' Alembert's Principle

$$\sum_{i=1}^{N} (F_i - P_i) \cdot \delta r_i = 0$$

where $P_i = \frac{\delta F_i}{\delta t}$ is the reversed effective force.

Components of Generalized Force—Let $q_1, q_2, \ldots, q_n$ are generalized coordinates and $r_i = r_i(q_1, q_2, \ldots, q_n)$, then for a system of n-particles, the components of generalized force Q_k associated with qk is—

$$Q_k = \sum_{i=1}^{N} F_i \cdot \frac{\delta r_i}{\delta q_k} = -\frac{\delta V}{\delta q_K}, \quad (K = 1, \ldots, n).$$

Lagrangian—$L = T - V$, where T is kinetic energy and V potential energy.

Lagrange's equation for holonomic system

$$\frac{d}{dt}\left(\frac{\delta T}{\delta q_k}\right) - \frac{\delta T}{\delta q_k} = Q_k \, (k = 1, \ldots, n)$$

Lagrange's equation for a conservative, holonomic dynamical system

$$\frac{d}{dt}\left(\frac{\delta T}{\delta q_k}\right) = \frac{\delta L}{\delta q_k} \qquad (k = 1, \ldots, n)$$

where $L = T - V$, a Lagrangian.

Lagrange's equations for conservative, non-holonomic system—

$$\frac{d}{dt}\left(\frac{\delta T}{\delta q_k}\right) - \frac{\delta L}{\delta q_k} = \sum_{j=1}^{m} \lambda_i a_{ik}, \quad (k = 1, \ldots, n)$$

where a_{ik} are function of q_k's and t and λ_t are constants ($i = 1, \ldots, m$).

Hamilton Principle

Hamilton's Principle—For a conservative holonomic system, the motion of a particle from time t_1 to time t_2 is such that line integral

$$S = \int_{t_1}^{t_2} L \, dt$$

has stationary (external) value for the correct path of motion. Here S is called Hamilton's principle function.

Conjugate momentum (Canonical momentum)—$P_k = \frac{\delta L}{\delta q_k}$ whenever the Lagrangian function does not contain a coordinate q_k explicitly, the generalized momentum P_k is a constant of motion *i.e.*, $P_k = \frac{\delta_L}{\delta q_k}$ = constant. The coordinate q_k are called cyclic or ignorable coordinate.

Hamiltonian Function

$$H = \sum_k P_k q_k - L$$

1. If time t does not appear in Lagrangian L explicity, then Hamiltonian function is constant in time and Hamiltonian function is conserved.

$$\frac{dH}{dt} = 0$$

$$\Rightarrow \quad H = \sum_k P_k q_k - L = \text{const.}$$

2. Hamiltonian H represents the total energy to the system and is conserved, provided the system is conservative.

$$H = T + V$$

Hamilton's Equation

$$q_k = \frac{\delta H}{\delta P_k} \text{ and } -P_k \frac{\delta H}{\delta q_k}$$

If any coordinate q_k is cyclic, *i.e.*, not contained in H, then

$$\frac{\delta H}{\delta q_k} = 0$$

or, $$P_k = 0$$

Euler-Lagrange's Equations

1. Let $f(y_1, y_2, \ldots, y_k, \ldots, y_n, y_1', y_2', \ldots, y'_k, \ldots y'_n, x)$ and $y_i(x) = y_i$,

   then Euler-Lagrange's equations are

$$\frac{\delta f}{\delta Y_k} - \frac{d}{dx}\left(\frac{\delta f}{\delta Y'_k}\right) = 0,$$

$$k = 1, 2, \ldots, n$$

2. If $f(Y, Y', x)$ defines a cure $y = y(x)$, then Euler-Lagrange's equation is

$$\frac{\delta f}{\delta Y} - \frac{d}{dx}\left(\frac{\delta f}{\delta Y'_k}\right) = 0$$

Modified Hamilton Principle

$$\delta \int_{t_1}^{t_2} \left(\sum_{k=1}^{n} P_k\, q_k - H\right) dt = 0$$

Hamilton's principle for non-conservative, non-holonomic system.

$$\delta \int_{t_1}^{t_2} (T + W)\, dt = 0$$

Principle of Least Action

1. For a conservative system

$$\Delta \int_{t_1}^{t_2} \sum_{k=1}^{n} P_k\, q_k\, dt = 0$$

   where $\int_{t_1}^{t_2} P_k\, q_k\, dt$ is called action.

2. Jacob's form

$$\Delta \int_{t_1}^{t_2} \sqrt{H - V(q)}\, dP = 0$$

3. In terms of arc length of particle trajectory

$$\Delta \int_{t_1}^{t_2} \sqrt{2m\,(H - V)}\, ds = 0$$

Equations of Motion of Rigid Bodies

Rigid Body—A rigid body is defined as a system of points subject to the holonomic constraints where the distances between all pairs of points remain constant throughout the motion, *i.e.*

$r_{ij} = c_{ij}$, where r_{ij} is the distance between ith and jth particles and c_{ij} is the constant.

The number of degrees of freedom for the general motion of a rigid body is six.

Body Co-ordinae System—A coordinate system, fixed in rigid body, is called a body coordinate system and its axes are called body set of axes.

Space Co-ordinate System—In this coordinate system axes are fixed in space, called space set of axes.

Eulerian Angles—They are defined as the three successive angles of rotation of rigid body about a point fixed in the body. We first rotate initial system of axes OXYZ (fixed by space) by an angle of counter clockwise about the Z-axis and the resultant coordinate system will be labeled as $\xi n \xi$. Secondly the intermediate axes $\xi n \xi$ are rotated about the ξ-axis counter clockwise by an angle θ to produce set of axes $\xi' n' \xi'$. The ξ'-axis is at the intersection of XY and $\xi' n$ planes and is known as lines of nodes. At least the axes $\xi n \xi$ are rotated counter-clockwise by an angle ψ about ξ axis to produce X′Y′Z′ system of axis (fixed in the body).

Here the angles (ϕ, θ, ψ) are known as Eularian angles.

Components of Angular Velocity—If ϕ, θ, ψ represents Euler's angle then ϕ, θ, ψ represents the angular velocity about the space Z-axis, line of nodes and body Z′ axis respectively, $\omega_\phi, \omega_\theta, \omega_\psi$ represents ϕ, θ, ψ respectively and called components of angular velocity ω.

Components of angular velocity along body set of axes—

$$\omega_x = \phi_x + \theta_x + \psi_x = \phi \sin\theta \sin\psi + \theta \cos\psi$$

$$\omega_y = \phi_y + \theta_y + \psi_y = \phi \sin\theta \cos\psi - \theta \sin\psi$$

$$\omega_z = \phi_z + \theta_z + \psi_z = \phi \cos\theta + \psi$$

Euler's Theorem—The general displacement of a rigid body with one point fixed is a rotation about some axis.

Chasle's Theorem—The general displacement of a rigid body is a translation with a rotation.

Angular Momentum and Inertia Tensor

Moment of Inertia

(a) Moment of inertia about X-axis.

$$I_{xx} = \sum_{i=1}^{n} m_i (y_i^2 + z_i^2)$$

(b) Moment of inertia about Y-axis

$$I_{yy} = \sum_{i=1}^{n} m_i (z_i^2 + y_i^2)$$

(c) Moment of inertia about Z-axis

$$I_{zz} = \sum_{i=1}^{n} m_i (x_i^2 + y_i^2)$$

Inertia Tensor—The elements I_{xx}, I_{xy}, I_{xz}, I_{yx}, I_{yy}, I_{yz} and I_{zx}, I_{zy}, I_{zz} are called components of I and I is called inertia tensor, *i.e.*

$$I = \begin{bmatrix} I_{xx} & I_{xy} & I_{xz} \\ I_{yx} & I_{yy} & I_{yz} \\ I_{zx} & I_{zy} & I_{zz} \end{bmatrix}$$

Principal Axes and Principal Moments of Inertia—If one choose the axes of the coordinate system fixed in the body with respect to which off diagonal elements disappear and only the diagonal elements remains in the inertia tensor, then such axes are called principal axes of the body and the corresponding moments of inertia a principal moment of inertia.

Euler's Equation of Motion for a Rigid Body

The x, y, z components of the torque is

$$T_x = I_{11} + (I_3 - I_2)_{23}$$

$$T_y = I_{22} + (I_1 - I_3)_{31}$$

$$T_z = I_{33} + (I_2 - I_1)_{12}$$

Principal of conservation of total rotational kinetic energy (in absence of torque)—

$$\frac{1}{2}\omega . J. = \text{constant}$$

Canonical Transformation—In canonical equation of motions, the generalized coordiantes $q_1, \ldots, q_n$ and generalized momentum $P_1, \ldots, P_n$ of a holonomic system are independent variables. The transformations of these $2n$ variables into a new set of variables

$$Q_i = Q_i (q, P, t) \text{ and } P_i + P_i (q, P, t)$$

are called canonical transformations if the motion equations of the system in new variables preserve the form of canonical equation of motion

$$Q_i = \frac{\delta H'}{\delta P}$$

and $$P_i = -\frac{\delta H'}{\delta Q_i}$$

where $H^i = H^i (Q, P, t)$ is a new Hamiltonian function.

Generating Function of the Canonical Transformation—The neccessary and sufficient condition for the transformation to be canonical is

$$\left[\sum_{i=1}^{n} P_i q_i - H (q, P, t)\, dt\right] - \left[\sum_{i=1}^{n} P_i Q_i - H^i (Q, P, t)\, dt\right] = dF$$

where F is a generating function of the canonical transformation. This generating function can be written in one of the following forms—

(i) $F_1 (q, Q, t)$, provided that only q_i, Q_i are treated independent.

(ii) $F_2 (q, P, t)$, provided that only q_i, P_i are treated independent

(iii) $F_3 (P, Q, t)$, provided that only P_i, Q_i are treated independent.

(iv) $F_4 (P, P, t)$, provided that only P_i, P_i are treated independent.

If $F = F_1$

$$P_i = \frac{\delta F_1}{\delta q_i}, \quad P_i = -\frac{\delta F}{\delta Q_i},$$

and $$H^i = H + \frac{\delta F_1}{\delta t}$$

If $F = F_2$

$$P_i = \frac{\delta F_2}{\delta q_i}, \quad Q_i = \frac{\delta F_2}{\delta P_i}$$

and $$H^i = H + \frac{\delta F_2}{\delta t}$$

If $F = F_3$

$$q_i = \frac{\delta F_3}{\delta P_i}, \quad P_i = -\frac{\delta F_3}{\delta Q_i}$$

and $$H^i = H + \frac{\delta F_3}{\delta t}$$

If $F = F_4$

$$q_i = \frac{\delta F_4}{\delta P_i}, \quad Q_i = -\frac{\delta F_4}{\delta P_i}$$

and $$H^i = H + \frac{\delta F_4}{\delta t}$$

Brackets

Lagrange's Bracket :

$$\{u, V\}_{q, P} = \sum_i \left(\frac{\delta q_i}{\delta u}\frac{\delta P_i}{\delta v} - \frac{\delta q_i}{\delta v}\frac{\delta P_i}{\delta u}\right)$$

$$= \sum_i \frac{\delta (q_i, P_i)}{\delta (u, v)}$$

Poisson's Bracket—

$$\{u, v\}_{q, P} = \sum_i \left(\frac{\delta u}{\delta q_i}\frac{\delta v}{\delta P_i} - \frac{\delta u}{\delta P_i}\frac{\delta v}{\delta q_i}\right)$$

$$= \frac{\delta (u, v)}{\delta (q_i, P_i)}$$

Phase Space—Phase space is a $2n$ dimensional space having coordinates $q_1, \ldots q_n$ and $P_1, \ldots P_n$.

Hamilton's equation of motion in Poisson's bracket

$$[q, H]_{q, P} = q$$

and $$[P, H]_{q, P} = P$$

Infinitesimal Contract Transformations—Those transformation in which the new set of coordinates (Q_k, P_k) differ from the old set (q_k, P_k) by infinitesimals.

Some Important Theorems

1. The transformation from variables $(q_1, q_2, \ldots, q_n, P_1, P_2, \ldots P_n)$ to variables $(Q_1, Q_2, \ldots Q_n, P_1, P_2, \ldots, P_n)$ will be a contract or canonical transformation if,

$$\sum_{i=1}^{n} P_r . d\,(Q_r - P_r\, dq_r) = dT$$

where dT is an exact differential.

2. **Poineare theorem**—Under Canonical transformations, the integral $J_1 = \int\int_S \sum_i dg_i\, dP_i$ remains invariant, where S is a two-dimensional surface in phase space.
3. Lagrange's bracket is canonical invariant.
4. Poisson's bracket is invariant under canonical transformation.
5. Jacobi's Identity for Poisson's brackets—If u, v, w are functions of q and P only, then $\{u, [v, w]\} + \{v, [w, u]\} + \{w\ \{u, v]\} = 0$.
6. If u, v are constants of motion, then $[u, v]$ is also constant of motion.

Small Oscillations and Normal Modes

Potential Energy and Equilibrium

System in Equilibrium—The system is said to be an equilibrium if the generalized forces acting on the system are equal to zero.

Stable Equilibrium—A system is in stable equilibrium, if a small displacement of the system from the rest position (after giving small energy) results in a small bounded motion about the equilibrium position.

Unstable Equilibrium—A system is in unstable equilibrium, if a small displacement of the system from the rest position (after giving small energy) results in an unbounded motion about the equilibrium position.

Neutral Equilibrium—A system is in neutral equilibrium, if the system on displacement has no tendency to move about or above the equilibrium position.

Two Coupled Oscillators—

$$m\ddot{x}_1 + Kx_1 + K'(x_1 + x_2) = 0$$

The equation of motion are

$$m\ddot{x}_2 + Kx_2 + K'(x_1 + x_2) = 0.$$

OBJECTIVE TYPE QUESTIONS

1. For a conservative system, generalized force—
   (A) Has necessarily the dimensions of force
   (B) Is a dimensionless quantity
   (C) Can not have dimensions of force
   (D) May have the dimensions of torque
2. Generalized coordinates—
   (A) Depend on each other
   (B) Are independent of each other
   (C) Are spherical coordinates
   (D) None of these
3. A rigid body moving freely in space has degrees of freedom—
   (A) Three (B) Six
   (C) Nine (D) Twelve

4. If the Lagrangian does not depend on time explicity—
   (A) The Hamiltonian is constant
   (B) Hamiltonian not constant
   (C) The kinetic energy is constant
   (D) The potential energy is constant

5. Choose the correct statements—
   (A) The angular momentum is not conserved for systems possessing rotational symmetry
   (B) If the Lagrangian of system is not invariant under translation along a direction, the corresponding linear momentum is conserved
   (C) If the Lagrangian of system is not invariant under translation along a direction, we can not say anything about the corresponding linear momentum
   (D) For a conservative system, the Hamiltonian is equal to the sum of kinetic and potential energies

6. A particle is constrained to move along the inner surface of a fixed hemispherical bowl. The number of degrees of freedom of the particle is—
   (A) One (B) Two
   (C) Three (D) Four

7. Choose the correct statements—
   (A) The angular momentum is not conserved for systems possessing rotational sysmmetry.
   (B) If the Lagrangian of a system is invariant under translation along a direction, the corresponding linear momentum is not conserved.
   (C) If the Lagrangian of a system is invariant under translation along a diection, we can not say anything about the corresponding linear momentum.
   (D) For a non conservative system, the Hamiltonian is equal to the sum of kinetic and potential energies.

8. Choose the correct statements—
   (A) The angular momentum is not conserved for systems possessing rotational symmetry.
   (B) If the Lagrangian of a system is invariant under translation along a direction, the corresponding linear momentum is conserved
   (C) If the Lagrangian system is not invariant under translation along a direction, we can not say anything about the corresponding linear momentum.
   (D) For conservative system, the Hamiltonian is not equal to the sum of kinetic and potential energies.

9. Choose the correct statements—
   (A) The angular momentum is conserved for systems possessing rotational symmetry.
   (B) If the Lagrangian of a system is invariant under translation along a direction, the corresponding linear momentum is not conserved.
   (C) If the Lagrangian of a system is not invariant under translation along a direction, one can not say anything about the corresponding linear momentum.
   (D) For a conservative system, the Hamiltonian is not equal to the sum of kinetic and potential energies.

10. The dimensions of generalized momentum—
   (A) Are always those of linear momentum
   (B) Are always those of angular momentum
   (C) May be those of angular momentum
   (D) None of these

11. The dimensions of generalized momentum—
   (A) Are always those of linear momentum
   (B) Are always those of angular momentum
   (C) May be those of linear momentum
   (D) None of these

12. Whenever the Lagrangian for a system does not contain a coordinate explicity—
   (A) P_k is the cyclic coordinate
   (B) P_k the generalized momentum, is a constant of motion
   (C) q_k is always zero
   (D) None of these

13. Whenever the Lagrangian for a system does not contain a coordinate explicity—
   (A) q_K is cyclic coordinate
   (B) P_K is cyclic coordinate
   (C) P_K is a constant of motion
   (D) None of these

14. 100 Rutherford differential scattering cross-section—
    (A) Has the dimensions of area
    (B) Has the dimension of solid angle
    (C) Is proportional to the square of the kinetic energy of the incident particle
    (D) None of these

15. A particle is moving under central force about a fixed centre of force. Choose the correct statements—
    (A) The motion of the particle is always an a circular path.
    (B) Its angular momentum is conserved
    (C) Its kinetic energy remains constant
    (D) None of these

16. A particle is moving under central force about a fixed centre of force. Choose the correct statements—
    (A) The motion of the particle is always on a circular path
    (B) Its kinetic energy remains constant
    (C) Motion of the particle takes place in a plane
    (D) None of these

17. If P_k and q_k (K = 1, 2, 3) represent the momentum and position coordinates respectively for a particle—
    (A) The phase space is six dimensional
    (B) The configuration space is six dimensional
    (C) The configuration space is three dimensional
    (D) None of these

18. If P_k and q_k (K = 1, 2, 3) represent the momentum and position coordinates respectively for a particle—
    (A) The phase space is six dimensional
    (B) The configuration space is six dimensional
    (C) The phase space is three dimensional
    (D) None of these

19. If the Poisson bracket of a function with the Hamiltonian vanishes—
    (A) The function depends upon time
    (B) The function does not depend on time explicity
    (C) The function is not the constant of motion
    (D) None of these

20. If the Poisson bracket of a function with the Hamiltonian vanishes—
    (A) The function depends upon time
    (B) The function is a constant of motion
    (C) The function is not the constant of motion
    (D) None of these

21. For a one-dimensional harmonic oscillator, the representative point in two dimensional phase space traces—
    (A) An ellipse
    (B) A parabola
    (C) A hyperbola
    (D) Always a straight line

22. Hamilton principal function δ and Hamilton characteristic function W for conservative system are related as, where E is the total energy and t is the time—
    (A) $\delta = W$
    (B) $\delta = W - Et$
    (C) $\delta = W + Et$
    (D) None of these

23. If we make a canonical transformation from the set of variables (P_k, q_k) to new set of variables (P_k, Q_k) and the transformed Hamiltonina is identically zero, then—
    (A) The new variables are cyclic
    (B) The new variables are not constant in time
    (C) The new variables are not cyclic
    (D) None of these

24. If we make a canonical transformation from the set of variables (P_k, q_k) to new set of variables (P_k, Q_k) and the transformed Hamiltonian is identically zero, then—
    (A) The new variables are constnat in time
    (B) The new variables are not constant in time
    (C) The new variables are not cyclic
    (D) None of these

25. In case of two coupled identical pendulums, in general—
    (A) The potential energy is a homogeneous quadratic functions, when expressed in terms of actual displacements.

(B) The potential energy is not a homogeneous quadratic functions, when expressed in terms of normal coordinates.

(C) The potential energy is a homogeneous quadratic functions, when expressed in terms of normal coordinates.

(D) None of these

26. In case of two coupled identical pendulums, in general—

(A) The potential energy is a homogoneous quadratic function, when expressed in terms of actual displacements.

(B) The potential energy is not a homogeneous guadratic functions, when expressed in terms of actual displacements.

(C) The potential energy is not a homogeneous quadratic functions when expressed in terms of normal coordinates

(D) None of these

27. In the case of symmetric mode for two coupled identical spring mass system—

(A) Both masses have equal and opposite displacements in phase

(B) Both masses vibrate with the frequency of single spring mass-system

(C) Both masses vibrate with a frequency different to the frequency of single spring-mass system

(D) None of these

28. In the case of symmetric mode for two coupled identical spring-mass system—

(A) Both masses have equal displacement in phase

(B) Both masses have equal and opposite displacement in phase

(C) Both masses vibrate with a frequency different to the frequency of single-spring-mass system

(D) None of these

29. In case of two coupled identical pendulums, oscillating in a plane—

(A) Each pendulum always execute simple harmonic motion

(B) The general motion can be expressed as a superposition of two simple harmonic motions of the same frequency.

(C) The general motion can be expressed as a superposition of two simple harmonic motions of the different frequency

(D) None of these

30. In case of two coupled identical pendulums, oscillating in a plane.

(A) Each pendulum always execute simple harmonic motion.

(B) Two pendulum always execute simple harmonic motion.

(C) The general motion can be expressed as a superposition of two simple harmonic motions of the same frequency.

(D) None of these

31. An example of stable equilibrium is—

(A) A pendulum in the rest position

(B) An egg standing on one end

(C) Book placed flat anywhere on table

(D) None of these

32. For two coupled oscillators, the equation of motion are—

(A) $m\ddot{x}_1 + Kx_1 + K'(x_1 + x_2) = 0$

$m\ddot{x}_2 + Kx_2 + K'(x_1 + x_2) = 0$

(B) $m\ddot{x}_2 + Kx_2 + K'(x_1 + x_2) = 0$ only

(C) $m\ddot{x}_1 + Kx_2 + K'(x_1 + x_2) = 0$ only

(D) None of these

33. An example of stable equilibrium is—

(A) A hanging spring-mass system in the stationary position

(B) An egg standing an one end

(C) A book placed flat anywhere an a table

(D) None of these

34. If a small displacement of the system from the rest position (after giving small energy) results in a small bounded motion about the equilibrium position. Then system is in—

(A) Stable equilibrium

(B) Unstable equilibrium

(C) Neutral equilibrium

(D) None of these

35. The system is said to be in equilibrium if the generalized forces acting on the system.

(A) Are equal to zero

(B) Are non zero
(C) Are infinite
(D) None of these

36. Poisson's bracket is—
(A) Invariant under canonical transformation
(B) Variant under canonical transformation
(C) Both (A) and (B)
(D) None of these

37. Unstable equilibrium—
(A) If a small displacement of the system from the rest position (after giving small energy) results in a small bounded motion about the equilibrium position
(B) If a small displacement of the system from the rest position (after giving small energy) results in an unbounded motion about the equilibrium position
(C) If the system on displacement has no tendency to move about or above the equilibrium position
(D) None of these

38. Lagrange's bracket is—
(A) Canonical invariant
(B) Cannonical variant
(C) Non-invariant
(D) None of these

39. Neutral equilibrium—
(A) If a small displacement of the system from the rest position (after giving small energy) results in a small bounded motion about the equilibrium position
(B) If a small displacement of the system from the rest position (after giving small energy) results in an unbounded motion about the equilibrium position
(C) If the system on displacement has no tendency to move about or above the equilibrium position
(D) None of these

40. Moment of inertia about z-axis is—
(A) $I_{xx} = \sum_{i=1}^{n} m_1 (y_i^2 + z_i^2)$
(B) $I_{yy} = \sum_{i=1}^{n} m_i (z_i^2 + y_i^2)$
(C) $I_{zz} = \sum_{i=1}^{n} m_i (x_i^2 + y_i^2)$
(D) None of these

41. The following $I_{zz} = \sum_{i=1}^{n} m_i (x_i^2 + y_i^2)$ represents—
(A) Moment of intertia about X-axis
(B) Moment of inertia about Y-axis
(C) Moment of inertia about Z-axis
(D) None of these

42. Stable equilibrium—
(A) If a small displacement of the system from the rest position (after giving small energy) results in a small bounded motion about the equilibrium position
(B) If a small displacement of the system from the rest position (after giving small energy) results in an unbounded motion about the equilibrium position
(C) If the system an displacement has no tendency to move about or above the equilibrium position
(D) None of these

43. Charle's theorem states—
(A) The general displacement of a rigid body with one point fixed is a rotation about some axis
(B) The general displacement of a rigid body is a translation with a rotation
(C) Lagrange's bracket is canonical invariant
(D) Poisson's bracket is invariant under canonical transformation

44. Moment of inertia about Y-axis is—
(A) $I_{xx} = \sum_{i=1}^{n} m_i (y_i^2 + z_i^2)$
(B) $I_{yy} = \sum_{i=1}^{n} m_i (z_i^2 + y_i^2)$
(C) $I_{zz} = \sum_{i=1}^{n} m_i (x_i^2 + y_i^2)$
(D) None of these

45. The following $I_{yy} = \sum_{i=1}^{n} m_i (z_i^2 + y_i^2)$ represent—
(A) Moment of inertia about X-axis
(B) Moment of inertia about Y-axis
(C) Moment of inertia about Z-axis
(D) None of these

46. The general displacement of a rigid body with one point fixed is a rotation about some axis—
    (A) Euler's theorem
    (B) Charle's theorem
    (C) Law of inertia
    (D) Law of force

47. If $f(y, y', x)$ defines a curve $y = y(x)$, then Euler-Lagrange's equation is—
    (A) $\frac{\delta f}{\delta y} \frac{d}{dx}\left(\frac{\delta f}{\delta y'_K}\right) = 0$
    (B) $\frac{\delta f}{\delta y} + \frac{d}{dx}\left(\frac{\delta f}{\delta y'_K}\right) = 0$
    (C) $\frac{\delta f}{\delta y} - \frac{d}{dx}\left(\frac{\delta f}{\delta y'_K}\right) = 0$
    (D) None of these

48. The general displacement of a rigid body is a translation with a rotation—
    (A) Euler's theorem
    (B) Charle's theorem
    (C) Law of inertia
    (D) Law of force

49. Moment of inertia about x-axis is—
    (A) $I_{xx} = \sum_{i=1}^{n} m_i (y_i^2 + z_i^2)$
    (B) $I_{yy} = \sum_{i=1}^{n} m_i (z_i^2 + y_i^2)$
    (C) $I_{zz} = \sum_{i=1}^{n} m_i (x_i^2 + y_i^2)$
    (D) None of these

50. A system is in ………, if the system on displacement has no tendency to move about or above the equilibrium position—
    (A) Stable equilibrium
    (B) Unstable equilibrium
    (C) Neutral equilibrium
    (D) None of these

51. A system is in ………, if a small displacement of the system from the rest position (after giving small energy) results in an unbounded motion about the equilibrium position—
    (A) Stable equilibrium
    (B) Unstable equilibrium
    (C) Neutral equilibrium
    (D) None of these

52. Euler's theorem states—
    (A) The general displacement of a rigid body with one point fixed is a rotation about some axis
    (B) The general displacement of a rigid body is a translation with a rotation
    (C) Lagrange's bracket is canonical invariant
    (D) Poisson's bracket is invriant under canonical transformation

53. Newton's First low of motion states—
    (A) A body continues in its state of rest or uniform motion, unless no external force is applied to it.
    (B) The time-rate of change of momentum is proportional to impressed force.
    (C) For every action there is always equal and opposite reaction
    (D) None of these

54. For every action there is always equal and opposite reaction—
    (A) Law of inertia
    (B) Law of force
    (C) Law of action and reaction
    (D) None of these

55. Lagrange's equations for conservative, non-holonomic system are—
    (A) $\left(\frac{\delta T}{\delta q_K}\right) - \frac{\delta L}{\delta q_K} = \sum_{i=1}^{m} \lambda_i, a_{iK}$, (K = 1, …, n)
    where a_{iK} are function of q_K·s and t and λ_i are constants (i = 1, …, m)
    (B) $\frac{d}{dt}\left(\frac{\delta T}{\delta q_K}\right) = \sum_{i=1}^{m} \lambda_i, a_{iK}$, (K = 1, …, n)
    where a_{iK} are function of q_K·s and t and λ_i are constants (i = 1, …, m)
    (C) $\frac{d}{dt}\left(\frac{\delta T}{\delta q_K}\right) - \frac{\delta L}{\delta q_k} = \sum_{i=1}^{m} \lambda_i, a_{iK}$, (K = 1, …, n) where a_{iK} are function of q_K·s and t and λ_t are constants (i = 1, …, m)
    (D) None of these

56. Let $f(y_1, y_2, \ldots, y_K, \ldots, y_n, y_1', y_2', \ldots, y_K', \ldots, y_x', x)$ and $y_i(x) = y_i$. Then Euler Lagrange's equations are—
    (A) $\frac{\delta f}{\delta y_k} + \frac{d}{dx}\left(\frac{\delta f}{\delta y'_k}\right) = 0$, K = 1, 2, …, n

(B) $\frac{\delta f}{\delta y_k} \frac{d}{dx}\left(\frac{\delta f}{\delta y'_k}\right) = 0$, K = 1, 2, …, n

(C) $\frac{\delta f}{\delta y_k} - \frac{d}{dx}\left(\frac{\delta f}{\delta y'_k}\right) = 0$, K = 1, 2, …, n

(D) None of these

57. If any coordinate q_k is cyclic, *i.e.*, not contained in H, then—

(A) $\frac{\delta H}{\delta q_K} = 0$

(B) $P_K = 0$

(C) (A) and (B) both true

(D) (A) or (B) are true

58. Hamilton's equation is—

(A) $q_k = \frac{\delta H}{\delta P_K}$

(B) $-P_K = \frac{\delta H}{\delta q_K}$

(C) (A) and (B) both

(D) None of these

59. Scleronomous constraints are—

(A) The constraints that can be expressed as equation form

(B) The constraints that can not be expressed as equation form

(C) Equation of constraints that contain time as explicit variable

(D) Equation of constraints that does not contains time as explicit variable

60. The constraints that can not be expressed as equation form—

(A) Holonomic constraints

(B) Non-holonomic constraints

(C) Rheonomous constraints

(D) Scleronomous constraints

61. Hamiltonion H is defined as—

(A) The total energy of the system

(B) The difference in energy of the system

(C) The product of energy of the system

(D) None of these

62. Hamiltonian function is—

(A) $H = L \sum_K P_K q_K$ (B) $H = \sum_K P_K q_K - L$

(C) $H = \sum_K P_K q_K + L$ (D) None of these

63. The Hamilton's principle states for a conservative holonomic system, the motion of a particle from time t_1 to time t_2 is such that line integral $S = \int_{T_1}^{T_2} L\, dt$ has …… for the correct path of motion. Here S is called Hamilton's principle function—

(A) Stationary (external) value

(B) Mean value

(C) Non-stationary value

(D) None of these

64. Lagrange's equation for holonomic system are—

(A) $\frac{d}{dt}\left(\frac{\delta T}{\delta q_K}\right)\frac{\delta T}{\delta q_K} = Q_K$ (K = 1, …, n)

(B) $\frac{d}{dt}\left(\frac{\delta T}{\delta q_K}\right) / \frac{\delta T}{\delta q_K} = Q_K$ (K = 1, …, n)

(C) $\frac{d}{dt}\left(\frac{\delta T}{\delta q_K}\right) - \frac{\delta T}{\delta q_K} = Q_K$ (K = 1, …, n)

(D) None of these

65. Rheonomous constraints are—

(A) The constraints that can be expressed as equation form

(B) The constraints that can not be expressed as equation form

(C) Equation of constraints that contain time as explicit variable

(D) Equation of constraints that does ot contains time as explicit variable

66. Non-holonomic constraints are—

(A) The constaints that can be expressed as equation form

(B) The constraints that can not be expressed as equation form

(C) Equation of constraints that contain time as explicit variable

(D) Equation of constraints that does not contain time as explicit variable

67. Lagrange's equations for a conservative, holonomic dynamical system are—

(A) $\left(\frac{\delta T}{\delta q_K}\right) = \frac{\delta L}{\delta q_K}$ (K = 1, …, n)

(B) $\left(\frac{\delta T}{\delta q_K}\right)^2 = \frac{\delta L}{\delta q_K}$ (K = 1, …, n)

(C) $\frac{d}{dt}\left(\frac{\delta T}{\delta q_K}\right) = \frac{\delta L}{\delta q_K}$ (K = 1, …, n)

(D) None of these

68. Lagrangian is defined as—
    (A) $L = T - V$, where T is kinetic energy and V potential energy
    (B) $L = TV$, where T is kinetic energy and V potential energy
    (C) $L = T \pm V$, where T is kinetic energy and V potential energy
    (D) $L = T/V$, where T is kinetic energy and V potential energy

69. In centre of mass-frame of refrence—
    (A) Total linear momentum is zero
    (B) Total linear momentum is less than zero
    (C) Total linear momentum is greater than zero
    (D) None of these

70. D′ Alembert's principle is—
    (A) $\sum_{i=1}^{N} (F_i - P_i) \cdot \delta r_i \neq 0$, where $P_i = \frac{\delta F_i}{\delta t}$ is the reversed effective force
    (B) $\sum_{i=1}^{N} (F_i - P_i) \cdot \delta r_i = 0$, where $P_i = \frac{\delta F_i}{\delta t}$ is the reversed effective force
    (C) $\sum_{i=1}^{N} (F_i - P_i) \cdot \delta r_i \geq 0$, where $P_i = \frac{\delta F_i}{\delta t}$ is the reversed effective force
    (D) $\sum_{i=1}^{N} (F_i - P_i) \cdot \delta r_i \leq 0$, where $P_i = \frac{\delta F_i}{\delta t}$ is the reversed effective force

71. Principle of virtual work states—
    (A) The work done is zero in the case of an arbitrary displacement of a system from a position of equilibrium
    (B) The work done is non-zero in the case of an arbitrary displacement of a system from a position of equilibrium
    (C) The work done is infinite in the case of an arbitrary displacement of a system from a position of equilibrium
    (D) None of these

72. Generalized coordinates are—
    (A) A set of dependent coordinates sufficient in number to describe completely the state of configuration of a dynamical system
    (B) A set of independent coordinates sufficient in number to describe completely the state of configuration of dynamical system
    (C) A set of dependent coordinates excesses in number to describe completely the state of configuration of a dynamical system
    (D) None of these

73. Centre of mass-frame of reference—
    (A) If the total external force on the system is zero, the total linear momentum is constant of motion
    (B) Total linear momentum is zero
    (C) The total angular momentum of a system of particles is conserved
    (D) None of these

74. Equation of constraints that contain time as explicit variable are referred as—
    (A) Holonomic constraints
    (B) Non-holonomic constraints
    (C) Rheonomous constraints
    (D) Scleronomous constraints

75. The constraints that can be expressed as equation form—
    (A) Holonomic constraints
    (B) Non-holonomic constraints
    (C) Rheonomous constraints
    (D) Scleronomous constraints

76. Limitations imposed on the motion of a system are referame of reference
    (A) Constraints
    (B) Frame of reference
    (C) Degree of freedom
    (D) None of these

77. Holonomic constraints are—
    (A) The constraint that can be expressed as equation form
    (B) The constraint that can not be expressed as equaton form
    (C) Equation of constraints that contain time as explicit variable
    (D) Equation of constraints that does not contain time as explicit variable

78. Equation of constraints that does not contain time as explicit variable are referred as—
    (A) Holonomic constraints
    (B) Non-holonomic constraints
    (C) Rheonomous constraints
    (D) Scleronomous constraints

79. Degree of freedom is—
    (A) The minimum number of independent coordinates (or variables) required to specify the system
    (B) The maximum number of independent coordinates (or variables) required to specify the system
    (C) The minimum number of dependent coordinates (or variables) required to specify the system
    (D) The maximum number of dependent coordinates (or variables) required to specify the system

80. The total angular momentum of a system of particles about a point—
    (A) Is the sum of angular momentum of the system about the centre of mass and the angular momentum about the reference point of the system mass, concentrated at the centre of the mass
    (B) Is the difference of a angular momentum of the system about the centre of mass and the angular momentum about the reference point of the system mass, concentrated at the centre of the mass
    (C) Is the product of angular momentum of the system about the centre of mass and the angular moment about the reference point of the system mass concentrated at the centre of the mass
    (D) None of these

81. Conservation of linear momentum—
    (A) If the total external force on the system is zero, the total linear momentum is constant of motion
    (B) Total linear momentum is zero
    (C) The total angular momentum of a system of particles is conserved
    (D) None of these

82. The centre of mass is defined as—
    (A) $R = \dfrac{\sum_i m_i r_i}{\sum_i m_i} = \dfrac{\sum_i m_i r_i}{M}$, where $\sum_i m_i = M$ (total mass of system)
    (B) $R = \dfrac{\sum_i m_i r_i}{\left(\sum_i m_i\right)^2} = \dfrac{\sum_i m_i r_i}{M^2}$ where $\sum_i m_i = M$ (total mass of system)
    (C) $R = \sum_i m_i r_i \sum_i m_i = M \sum_i m_i r_i$, where $\sum_i m_i =$ M (total mass of system)
    (D) None of these

83. Conservation of total angular momentum—
    (A) If the total external force on the system is zero, the total linear momentum is constant of motion
    (B) In centre of mass-frame of reference, total linear momentum is zero
    (C) The total angular momentum of a system of particles is conserved
    (D) None of these

84. If the work done by forces on the particle around a closed path in the force field is zero—
    (A) The force are conservative
    (B) The forces are non conservative
    (C) Both (A) and (B) are true
    (D) None of these

85. Relation between cartesian and spherical coordinate system—
    (A) $\begin{cases} x = r \sin\theta \cos\phi \\ y = r \sin\theta \sin\phi \\ z = r \cos\theta \end{cases}$
    (B) $\begin{cases} x = r \sin\theta \sin\phi \\ y = r \sin\theta \sin\phi \\ z = r \sin\theta \end{cases}$
    (C) $\begin{cases} x = r \sin\theta \cos\phi \\ y = r \sin\theta \sin\phi \\ z = r \end{cases}$
    (D) None of these

86. Relation between cartesian and cylindrical coordinate system—
    (A) $\begin{cases} r = \sqrt{x^2 y^2 z^2} \\ \theta = \tan^{-1} y/x \\ z = z \end{cases}$
    (B) $\begin{cases} r = \sqrt{x^2 + y^2 + z^2} \\ \theta = \tan^{-1} y/x \\ z = z \end{cases}$

(C) $\begin{cases} r = \sqrt{x^2 + y^2 + z^2} \\ \theta = \tan y/x \\ z = z \end{cases}$

(D) None of these

87. Energy conservation law states—
    (A) The sum of kinetic energy and potential energy (*i.e.* total mechanical energy) of a particle remains constant in a conservative force field
    (B) The sum of kinetic energy and potential energy (*i.e.* total mechanical energy) of a particle remains not constant in conservative force field.
    (C) The sum of kinetic energy and potential energy *i.e.* (total mechanical energy)of a particle remains constant in non-conservative force field
    (D) None of these

88. If W_{12} is the work done by an external force F upon a particle in displacing from point 1 to 2 and the change in potential energy from point 1 to 2 is V_1 and V_2 respectively. Then—
    (A) $W_{12} = \int_1^2 F.dr = V_1 + V_2$
    (B) $W_{12} = \int_1^2 F.dr = V_1 - V_2$
    (C) $W_{12} = \int_1^2 F.dr = V_1 V_2$
    (D) None of these

89. If the force is conservative, the work done on the particle—
    (A) Around a closed path in the force field is zero
    (B) Around a open path in the force field is zero
    (C) Around a closed path in the force field is non-zero
    (D) None of these

90. If W_{12} is the work done by an external force F upon a particle in displacing from point 1 to 2 and the change in kinetic energy from point 1 to 2 is T_1 and T_2 respectively. Then—
    (A) $W_{12} = \int_1^2 F.dr = T_1 T_2$
    (B) $W_{12} = \int_1^2 F.dr = T_1 + T_2$
    (C) $W_{12} = \int_1^2 F.dr = T_2 - T_1$
    (D) None of these

91. Newton's second law of motion states—
    (A) A body continues in its state of rest or uniform motion, unless no external force is applied to it
    (B) The time rate of change of momentum is proportional to impressed force
    (C) For every action there is always equal and opposite reaction
    (D) None of these

92. The time-rate of change of momentum is proportional to impressed force—
    (A) Law of inertia
    (B) Law of force
    (C) Law of action and reaction
    (D) None of these

93. The following represents the spherical coordinates—
    (A) (x, y, z) (B) (r, θ, ϕ)
    (C) (r, θ, z) (D) None of these

94. The following represents the cylindrical coordinate—
    (A) (x, y, z) (B) (r, θ, ϕ)
    (C) (r, θ, z) (D) None of these

95. The following represents the cartesian coordinate—
    (A) (x, y, z) (B) (r, θ, ϕ)
    (C) (r, θ, z) (D) None of these

96. An inertial frame is—
    (A) Non-accelerated frame of reference
    (B) Accelerated frame of reference
    (C) Both (A) and (B)
    (D) None of these

97. A frame of reference in which law of inertia holds—
    (A) Galilean frames of reference
    (B) Non Newtonian frame of reference
    (C) Accelerated frames
    (D) None of these

98. Newton's third law of motion states—
    (A) A body continues in its state of rest or uniform motion, unless no external force is applied to it

(B) The time-rate of change of momentum is proportional to impressed at force
(C) For every action there is always equal and opposite reaction
(D) None of these

99. A body continues in its state of rest or uniform motion, unless no external force is applied to it—
(A) Law of inertia
(B) Law of force
(C) Law of action and reaction
(D) None of these

100. Non inertial frame is—
(A) Non-accelerated frame of reference
(B) Accelerated frame of reference
(C) Both (A) and (B)
(D) None of these

101. If a coordinate system is attached to a rigid body and one deseribe the position of any particle relative to it, then such coordinate system is called ……….
(A) Frame of reference
(B) Space-time reference system
(C) Coordinate system
(D) None of these

102. If the physical phenomena occur in a space, its position is known as ……… the time of occurrence and the point taken together are called ……….
(A) Point, Event (B) Event, Point
(C) Space, Event (D) None of these

103. Relation between cartesian and spherical coordinate systems—

(A) $\begin{cases} r = \sqrt{x^2 + y^2 + z^2} \\ \theta = \tan^{-1} \sqrt{\dfrac{x^2 + y^2}{z}} \\ \phi = \tan^{-1} y/x \end{cases}$

(B) $\begin{cases} r = \sqrt{x^2 y^2 z^2} \\ \theta = \tan^{-1} \sqrt{\dfrac{x^2 y^2}{z}} \\ \phi = \tan y/x \end{cases}$

(C) $\begin{cases} r = \sqrt{x^2 + y^2/z^2} \\ \theta = \tan yz/x \\ \phi = \tan^{-1} y/x \end{cases}$

(D) None of these

104. Relation between cartesian and cylindrical coordinate system—

(A) $\begin{cases} x = r\cos\theta \\ y = r\sin\theta \\ z = z \end{cases}$ (B) $\begin{cases} x = r\sin\theta \\ y = r\cos\theta \\ z = z \end{cases}$

(C) $\begin{cases} x = r\cos\theta \\ y = z \\ z = r\sin\theta z \end{cases}$ (D) None of these

105. The following (r, θ, z) are the coordinate of—
(A) Cartesian coordinate system
(B) Cylindrical coordinate system
(C) Spherical coordinate system
(D) None of these

106. The following (r, θ, ϕ) are the coordinate of—
(A) Cartesian coordinate system
(B) Cylindrical coordinate system
(C) Spherical coordinate system
(D) None of these

107. The following (x, y, z) are the coordiante of—
(A) Cartesian coordinate system
(B) Cylindrical coordinate system
(C) Spherical coordinate system
(D) None of these

108. Relation between cartesian and polar coordinate system.
(A) $r = \sqrt{x^2 y^2}$ and $\theta = \tan y/x$
(B) $r = \sqrt{x^2 + y^2}$ and $\theta = \tan^{-1} y/x$
(C) $r = \sqrt{x^2/y^2}$ and $\theta = \tan^{-1} y/x$
(D) None of these

109. Relation between cartesian and polar coordinate system—

(A) $\begin{cases} x = r\cos\theta \\ y = r\sin\theta \end{cases}$

(B) $\begin{cases} x = r\sin\theta \\ y = r\cos\theta \end{cases}$

(C) $\begin{cases} x = r\tan\theta \\ y = r\sin\theta \end{cases}$

(D) None of these

110. An alternative and superior schemes in classical mechanics, developed by D′ Alembert, Langrange, Hamilton and others. Here scalar quantities such as energy rather than vector quantities are used and dynamical

relations are obtianed by systematic process of differentiation—
(A) Newtonian (vectorial) mechanics
(B) Analytical mechanics
(C) Quantum mechanics
(D) None of these

111. Classical mechanics that deals with the Newton's laws and their consequences. Here vector quantities such as force, acceleration, momentum etc. are used in referred as—
(A) Newtonian (vectorial) mechanics
(B) Quantum mechanics
(C) Analytical mechanics
(D) None of these

112. The mechanics based on Newton's law of motion and alternatively developed by Lagrange, Hamilton and others is—
(A) Classical mechanics
(B) Relative mechanics
(C) Quantum mechanics
(D) None of these

113. Following is true for mechanics—
(A) It deals with physical objects in motion under the influence of external and internal interaction
(B) It deals with physical objects at rest under the influence of external and internal interaction
(C) Both (A) and (B)
(D) None of these

Answers

1. (D)	2. (B)	3. (B)	4. (A)	5. (D)
6. (B)	7. (C)	8. (B)	9. (A)	10. (C)
11. (C)	12. (B)	13. (A)	14. (A)	15. (B)
16. (C)	17. (C)	18. (A)	19. (B)	20. (B)
21. (A)	22. (B)	23. (A)	24. (A)	25. (C)
26. (B)	27. (B)	28. (A)	29. (C)	30. (B)
31. (A)	32. (A)	33. (A)	34. (A)	35. (A)
36. (A)	37. (A)	38. (A)	39. (C)	40. (A)
41. (B)	42. (A)	43. (B)	44. (B)	45. (B)
46. (A)	47. (C)	48. (B)	49. (A)	50. (C)
51. (B)	52. (A)	53. (A)	54. (C)	55. (C)
56. (C)	57. (D)	58. (D)	59. (D)	60. (B)
61. (A)	62. (B)	63. (A)	64. (C)	65. (C)
66. (B)	67. (B)	68. (A)	69. (A)	70. (B)
71. (A)	72. (B)	73. (B)	74. (C)	75. (A)
76. (A)	77. (A)	78. (D)	79. (A)	80. (A)
81. (A)	82. (A)	83. (C)	84. (A)	85. (A)
86. (B)	87. (A)	88. (B)	89. (A)	90. (C)
91. (B)	92. (B)	93. (B)	94. (C)	95. (A)
96. (A)	97. (A)	98. (C)	99. (A)	100. (B)
101. (A)	102. (A)	103. (A)	104. (A)	105. (C)
106. (D)	107. (A)	108. (B)	109. (A)	110. (B)
111. (A)	112. (C)	113. (C)		