B.Sc. (Semester - 5)
Subject: Physics
Course: US05CPHY01
Classical Mechanics

Question Bank
UNIT: I

Multiple choice questions:

(1) The gravitational force between two masses is _____
(a) Repulsive (b) **Attractive**
(c)Zero (d) Infinity

(2) The value of universal gravitational constant G is _____
(a) 4×10^{42} Nm^2/Kg^2 (b)$6.67\times10^{+11}$ Nm^2/Kg^2
(c) $9.81cm/sec^2$ (d) **6.67×10^{-11} Nm^2/Kg^2**

(3) The value of the permittivity of the vacuum ϵ_0 is _____
(a) 8.1×10^{12} $coul/Nm^2$ (b) 8.1×10^{12} $coul^2/Nm^2$
(c) **8.9×10^{-12} $coul^2/Nm^2$** (d) 8.9×10^{12} $coul^2/Nm^2$

(4) The electrostatic forces are very much _____than the gravitational forces in the interaction of atomic and subatomic particles.
(a) Poor (b) **Stronger**
(c) Equal (d) Lower

(5) The potential due to point charge falls off as _____
(a) r (b) r^2
(c) $1/r^2$ (d) **1/r**

(6) The potential due to dipole falls off as _____
(a) r (b) r^2
(c) **$1/r^2$** (d) 1/r

(7) The field intensity of a dipole varies as _____
(a) **$1/r^3$** (b) r^2
(c) $1/r^2$ (d) 1/r

(8) The electrostatic force between two unlike charges are _____
(a) Zero (b) **attractive**
(c) repulsive (d) infinity

(9) The electrostatic force between two like charges are _____
(a) Zero (b) attractive
(c) **repulsive** (d) infinity

(10) The angular momentum is _____ in a central force field.
(a) Zero (b) Not conserved
(c) infinity (d) **conserved**

(11) The areal velocity of the particle in a central force field is _____
(a) Zero (b) **conserved**
(c) infinity (d) Not conserved

(12) At the turning point in an arbitrary potential field the radial velocity is _____
(a) **Zero** (b) 1
(c) infinity (d)1/2

(13) For hyperbolic orbit the values of energy E and eccentricity ϵ are _____
(a) E=0 and ϵ>1 (b) **E>0 and ϵ>1**
(c) E>0 and ϵ=1 (d) E>0 and ϵ=0

(14) For parabolic orbit the values of energy E and eccentricity ϵ are _____
(a) **E=0 and ϵ=1** (b) E>0 and ϵ>1
(c) E>0 and ϵ=1 (d) E>0 and ϵ=0

(15) For elliptical orbit the values of energy E and eccentricity ϵ are _____
(a) E=0 and ϵ>1 (b) E>0 and ϵ>1
(c) **E<0 and ϵ<1** (d) E>0 and ϵ=0

(16) For circular orbit the value of eccentricity _____
(a) ϵ>1 (b) ϵ≥1
(c) ϵ<1 (d) **ϵ=0**

(17) All the planet moves around the Sun in _____ orbit.
(a) circular (b) parabolic
(c) hyperbolic (d) **elliptical**

Short Questions:

1. State the Newton's law of gravitation
2. State the Coulomb's inverse square law
3. What is the ratio of electrostatic force to gravitational force in the case of electron
4. Define equipotential surface
5. State the Gauss' law for the flux
6. Write the Poisson's equation in Cartesian coordinate system
7. Write the Laplace's equation
8. Define electric dipole
9. Write the expression of potential due to electric dipole at a distance r
10. Write the equation of motion for two body moving under the action of internal forces
11. Define the central force field
12. State the inverse square law force
13. State the Kepler's first law of planetary motion
14. State the Kepler's second law of planetary motion
15. State the Kepler's third law of planetary motion
16. Define elliptical orbit
17. Define hyperbolic orbit
18. Define parabolic orbit
19. Which force is required to obtain circular motion of the particle around the centre of the force

Long Questions:

1. Explain the laws of gravitational and electromagnetic forces and show that electromagnetic forces are much stronger than the gravitational forces in the interaction of atomic and subatomic particles.
2. Derive the expressions for gravitational and electrostatic fields and potentials.
3. Derive the Gauss' law for electrostatic fields.
4. Using the Gauss' law obtain the expression of Laplace equation.
5. Derive the expressions of fields and potentials for dipole.
6. Derive the equation of motion of equivalent one body and explain why apple falls toward the earth and not the earth towards the apple?
7. Discuss the motion of a particle in a central force field and prove the conservation laws of linear momentum and total energy.
8. Discuss the motion of a particle in an arbitrary potential field.
9. Explain the motion of a particle in an inverse square law force field with special cases.
10. Derive the polar equation of elliptical orbit.
11. State the Kepler's law of planetary motion and derive the Kepler's third law of planetary motion.

UNIT-II

Multiple choice questions:

(1) The degree of freedom for a free particle in space are _____
(a) one (b) two
(c) **three** (d) zero

(2) The number of independent variable for a free particle in space are _____
(a) zero (b) one
(c) two (d) **three**

(3) The degree of freedom for N particles in space are _____
(a) 2N (b) **3N**
(c) N (d) zero

(4) The number of independent variable for a free particle in space are _____
(a) N (b) 2N
(c) **3N** (d) zero

(5) _____ constraints are independent of time.
(a) Holonomic (b) Non-Holonomic
(c) **Scleronomous** (d) Rheonomous

(6) _____ constraints are time dependent.
(a) Holonomic (b) Non-Holonomic
(c) Scleronomous (d) **Rheonomous**

(7) The generalized coordinates for motion of a particle moving on the surface of a sphere of radius 'α ' are _____
(a) α and θ (b) α and ϕ
(c) **θ and ϕ** (d) 0 and ϕ

(8) The Lagrangian equations of motion are _____ order differential equations.
(a) first (b) **second**
(c) zero (d) forth

(9) The Lagrange's equations of motion for a system is equivalent to _____ equations of motion.
(a) **Newton's** (b) Laplace
(c) Poisson (d) Maxwell's

(10) The Lagrangian function is define by _____
(a) $L = F + V$ (b) $\boldsymbol{L = T - V}$
(c) $L = T + V$ (d) $L = F - V$

(11) The Hamiltonian function is define by _____
(b) $H = F + V$ (b) $H = T - V$
(c) $\boldsymbol{H = T + V}$ (d) $H = F - V$

Short Questions:

1. Define constraint motion.
2. What is degree of freedom?
3. What is virtual displacement?
4. Define Holonomic and non-holonomic constraints.
5. Define Scleronomous and Rheonomous constraints.
6. State the D'Alembert's principle in words.
7. Write the Lagrange's equation of motion for conservative system.
8. Write the Lagrange's equation of motion for non-conservative system.
9. Define cyclic coordinates.
10. Construct the Lagrangian for Atwood's machine.
11. Construct the Lagrangian for Spherical pendulum.

Long Questions:

1. What are constraints? Explain, giving examples, the meaning of holonomic and nonholonomic constraints.
2. Explain the meaning of Scleronomous and Rheonomous constraints. Give illustrations of each.
3. Is the Lagrangian formulation more advantageous than the Newtonian formulation? Why?
4. What do you understand by cyclic coordinates? Show that the generalized momentum corresponding to a cyclic coordinate is a constant of motion.
5. Explain the term 'virtual displacement' and state the principle of virtual work.
6. Describe the use of Rayleigh's dissipation function.
7. Define the Hamiltonian. When is it equal to the total energy of the system? When is it conserved?
8. What is meant by a configuration space? How is this concept used to describe the motion of a system of particles?
9. What are constraints? Discuss holonomic and Non-holonomic constraints with illustration.
10. Discuss various types of constraints with illustration
11. Discuss the concept of generalized coordinates with illustrations.

12. Discuss the virtual work done for motion of a system and derive the mathematical statement of D'Alembert's statement.
13. Derive the Lagrange's equation of motion for a conservative system from D'Alembert's principle.
14. Derive the general expression of kinetic energy and find the kinetic energy of double pendulum from it.
15. What is cyclic coordinates? Show that total energy is conserved.
16. Construct the Lagrangian of Atwood machine and derive its the equation of motion.
17. Construct the Lagrangian of spherical pendulum and derive its the equation of motion. Also show the conservation of total energy and constant of motion.

UNIT: III

Multiple choice questions:

(1) A frame of reference moving with a constant velocity relative to a fixed frame is called _____ frame
(b) **inertial** (b) non inertial
(c) real (d) imaginary

(2) A frame of reference is accelerated relative to a fixed frame is called _____ frame
(b) inertial (b) **non inertial**
(c) real (d) imaginary

(3) All the frames of reference that are rotating relative to a fixed frame of reference are the _____ frame of reference
(b) inertial (b) **non inertial**
(c) real (d) imaginary

(4) If the moving frame of reference is accelerated the effective force acting on the particle is _____ than the actual force
(a) zero (b) equal
(c) **smaller** (d) higher

(5) Newton's laws of motion are valid in the two systems moving with a _____ relative velocity
(b) accelerated (b) double
(c) non uniform (d) **uniform**

(6) The term $\vec{\omega} \times (\vec{\omega} \times \vec{r})$ is called _____
(a) linear acceleration (b) angular acceleration
(c) **centripetal acceleration** (d) coriolis acceleration

(7) The term $2\vec{\omega} \times \left(\frac{d\vec{r}}{dt}\right)_{rot}$ is called _____
(a) linear acceleration (b) angular acceleration
(c) centripetal acceleration (d) **coriolis acceleration**

(8) In a rotational motion centripetal acceleration directed to _____ of the circle
(a) upwards (b) outwards
(c) inwards (d) **centre**

(9) In a cyclone the wind whirls in the _____ sense in the northern hemisphere

(a) upwards (b) downwards
(c) clockwise (d) **anticlockwise**

(10) In a cyclone the wind whirls in the _____ sense in the sourthern hemisphere
(a) upwards (b) downwards
(c) **clockwise** (d) anticlockwise

(11)In the rotation of a rigid body the directions of the angular velocity and the angular momentum are _____
(a) same (b) **different**
(c) perpendicular (d) parallel

(12)The moment of inertia is a tensor of rank _____
(a) one (b) **two**
(c)three (d) zero

(13) A rigid body have _____ degree of freedom
(a) one (b) two
(c)three (d) **six**

(14) If $I_1 = I_2 = I_3$, then the body is called _____
(a) **spherical top** (b) symmetrical top
(c)asymmetrical top (d) rotator

(14) If $I_1 = I_2 \neq I_3$, then the body is called _____
(a) spherical top (b) **symmetrical top**
(c)asymmetrical top (d) rotator

(15) If $I_1 \neq I_2 \neq I_3$, then the body is called _____
(a) spherical top (b) symmetrical top
(c)**asymmetrical top** (d) rotator

(16) If $I_1 = I_2$ and $I_3 = 0$, then the body is called _____
(a) **spherical top** (b) symmetrical top
(c)asymmetrical top (d) rotator

(17) In a torque free motion of a rigid body, the _____ of the body is a constant vector
(a) angular velocity (b) linear velocity
(c)**angular momentum** (d) angular acceleration

(18) _____ must be applied to maintain the rotation of the system about given axis
(a) force (b) momentum
(c)velocity (d) **torque**

Short Questions:

1. Define rigid body
2. State the Euler's theorem
3. State the Chasles' theorem
4. Write the expressions of components of angular momentum
5. Derive the expression of kinetic energy of rotation of rigid body
6. Show that the directions of the angular velocity and the angular momentum are different
7. Define spherical top and asymmetric top
8. Define symmetrical top and rigid rotator

9. What you mean by torque free motion
10. Define precessional velocity

Long Questions:

1. State and prove Euler's theorem
2. Derive the expressions of angular momentum and kinetic energy
3. Discuss the inertia tensor of rigid body
4. Derive the Euler's equations of the motion and find the relation between the rate at which work done by the torque and the rate of change of kinetic energy
5. Discuss the torque free motion of a rigid body and derive the expression $A^2 = \frac{L^2 - 2I_3 T}{I_1 (I_1 - I_3)}$
6. Discuss the Euler's angles of the rigid body with neat diagrams
7. Discuss the motion of a symmetrical top and derive the expressions of its total energy and precessional velocity

UNIT: IV

Multiple choice questions:

(1) The n-dimensional space is called _____ space
(c) solar (b) **configuration**
(c)real (d) zero

(2) In variational principle the line integral of some function between two end points is _____
(c) zero (b) infinite
(c) **extremum** (d) one

(3) The shortest distance between two points in a plane is _____
(c) circular (b) hyperbolic
(c) parabolic (d) **straight line**

(4) The path of a particle is_____when it is moving under constant conservative force field
(a) **cycloid** (b) hyperbolic
(c) parabolic (d) straight line

(5) The equation of constraints is _____ for a cylinder rolling on inclined plane
(c) $r\, d\emptyset - dx = 0$ (b) $\boldsymbol{r\, d\theta - dx = 0}$
(c) $r\, dr - dx = 0$ (d) $r\, dx - dx = 0$

(6) The equation of constraints for a simple pendulum is _____
$(a)\, r\, d\theta - l = 0$ (b) $r + l = 0$
(c) $r\, d\theta + l = 0$ (d) $\boldsymbol{r - l = 0}$

(7) The angle of flies off for a particle moving on spherical surface is _____
(b) $\phi_C = cos^{-1}\left(\frac{3}{2}\right)$ (b) $\phi_C = sin^{-1}\left(\frac{3}{2}\right)$
(c) $\boldsymbol{\phi_C = cos^{-1}\left(\frac{2}{3}\right)}$ (d) $\phi_C = sin^{-1}\left(\frac{3}{2}\right)$

Short Questions:

1. What is configuration space?
2. State the variational principle
3. Define geodesic line
4. Write the equation of cycloid when a particle is moving in a constant conservative force field
5. State the Hamilton's principle
6. Show that the Lagrangian and Newtonian equation are equivalent
7. What is undetermined multiplier?
8. Write the Lagrangian for a cylinder rolling on inclined plane
9. Write the Lagrangian of simple pendulum in terms of spherical polar coordinates
10. Write the Hamilton's equation of motion

Long Questions:

1. Describe the configuration space
2. Discuss the technique of calculus of variation and derive the general Euler's equation
3. Derive the Euler's equation using δ- notation
4. To show that the shortest distance between two points in a plane is a straight line
5. Discuss the shortest time problem for a motion of a particle in a constant conservative force field
6. Show that the extremum value of the distance between the two points on the surface of a sphere is an arc of a circle whose centre lies at the centre of the sphere
7. State the Hamilton's principle and derive the Lagrange's equation of motion
8. Derive the Hamilton's principle from Newtonian formulation
9. Construct the Lagrangian for series and parallel connection of inductance L, resistance R and capacitor C with an external electromotive force ε(t)
10. Describe the Lagrange's undetermined multiplier with illustration
11. Derive the Lagrange's equation of motion for Non-holonomic system
12. Construct the Lagrangian and derive the equations of motion for a cylinder rolling on inclined plane using undetermined multiplier
13. Derive the equation of motion for a simple pendulum using undetermined multiplier
14. Construct the Lagrangian for motion of a particle on a sphere and derive the equations of motion using undetermined multiplier
15. Derive the Schrodinger wave equation using variational principle
16. Derive the Hamilton's equation of motion