

Level : B.Sc.
Year : II

Course : PHYS 213
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No. :

Date JAN 17 2018

SECTION "A"

[20 Q. × 1 = 20 marks]

Choose and tick the most appropriate answer. Symbols have their usual meanings unless stated and missing parameters can be assumed suitably.

- Which one of the following statements is NOT CORRECT?
[a] Rheonomous constraints have explicit time dependence.
[b] Scleronomous constraints have no explicit time dependence.
[c] If a coordinate does not appear in Lagrangian, then it is called cyclic.
[d] The walls of a gas container constitute a holonomic constraint.
- A particle moves in a plane under the influence of a force, acting toward a centre of force, whose magnitude is

$$F = \frac{1}{r^2} \left(1 - \frac{\dot{r}^2 - 2\ddot{r}r}{c^2} \right),$$

where r is the distance of the particle to the centre of force. The generalized potential that will result in such a force is

[a] $U = \frac{1}{r} \left[1 + \frac{\dot{r}^2}{rc^2} \right]$ [b] $U = \frac{1}{r} \left[1 + \frac{r^2}{c^2} \right]$ [c] $U = \frac{1}{\dot{r}} \left[1 + \frac{\dot{r}^2}{c^2} \right]$ [d] $U = \frac{1}{r} \left[1 + \frac{\dot{r}^2}{c^2} \right]$

- A simple pendulum of length L mass M swings back and forth with period P . If the mass is doubled, what is the new period?
[a] $\sqrt{2} P$ [b] P [c] $2P$ [d] $\frac{1}{\sqrt{2}} P$
- The Lagrangian for a mechanical system is $L = \frac{1}{2} [m\dot{q}^2 - kq^2]$ where q is a generalized coordinate and m and k are constants. The equation of motion for this system is
[a] $m\dot{q} + kq = 0$ [b] $k\ddot{q} + mq = 0$ [c] $m\ddot{q} + kq = 0$ [d] $m\dot{q} + k\dot{q} = 0$
- Which one of the following statements is NOT CORRECT?
[a] A central force is a non-conservative force.
[b] Central force motion is always motion in a plane.
[c] The angular momentum of the particle subjective to central force is conserved.
[d] If a particle moves in a central force field, then the areal velocity is constant.
- A body under the action of inverse square force will follow an elliptic path if the total energy is
[a] $E=0$ [b] $E \neq 0$ [c] $E \ll 0$ [d] $E \ll 1$

7. Equation of the orbit of a particle under the action of central force is given by $r = ae^{b\theta}$. The corresponding force is

[a] $f(r) = -\frac{l^2(a^2+1)}{mr^3}$

[b] $f(r) = -\frac{l^2(b^2+1)}{mr^2}$

[c] $f(r) = -\frac{l(b^2+1)}{r^3}$

[d] $f(r) = -\frac{l^2(b^2+1)}{mr^3}$

8. The reduced mass of Hydrogen atom μ_H (m_e = mass of electron, m_p = mass of proton) nearly equal to

[a] m_e

[b] m_p

[c] $\frac{m_e + m_p}{2}$

[d] $\frac{1}{m_e} + \frac{1}{m_p}$

9. The coordinate system $C' \equiv Ox'_1x'_2x'_3$ is obtained by rotating the coordinate system $C \equiv Ox_1x_2x_3$ through an angle of ψ about the axis Ox_1 . The transformation matrix between C and C' is

[a] $\begin{pmatrix} 1 & 0 & 0 \\ 0 & \psi & -\psi \\ 0 & \psi & \psi \end{pmatrix}$

[b] $\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\psi & \sin\psi \\ 0 & -\sin\psi & \cos\psi \end{pmatrix}$

[c] $\begin{pmatrix} 0 & 0 & 0 \\ 0 & \cos\psi & \sin\psi \\ 0 & -\sin\psi & \cos\psi \end{pmatrix}$

[d] $\begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\psi & -\sin\psi \\ 0 & \sin\psi & \cos\psi \end{pmatrix}$

10. The differential scattering cross-section for scattering of α -particles by an atomic nucleus is given by

[a] $\sigma(\Theta) = \frac{1}{4} \left[\frac{ZZ'e^2}{2E} \right]^2 \frac{1}{\sin^4 \frac{\Theta}{2}}$

[b] $\sigma(\Theta) = \frac{1}{4} \left[\frac{ZZ'e^2}{2E} \right]^2 \frac{1}{\cos^4 \frac{\Theta}{2}}$

[c] $\sigma(\Theta) = \frac{1}{4} \left[\frac{ZZ'e^2}{2E} \right] \frac{1}{\sin^4 \frac{\Theta}{2}}$

[d] $\sigma(\Theta) = \frac{1}{4} \left[\frac{ZZ'e^2}{2E} \right]^2 \sin^4 \frac{\Theta}{2}$

11. A 2.0-kg object moving with a velocity of 5.0 m/s in the positive x direction strikes and sticks to a 3.0-kg object moving with a speed of 2.0 m/s in the same direction. How much kinetic energy is lost in this collision?

[a] 2.4 J

[b] 9.6 J

[c] 5.4 J

[d] 0.6 J

12. The _____ is a phenomenon, related to the Earth's rotation that causes air and ocean currents to deflect to the right to their direction of motion in the northern hemisphere and to the left of their direction of motion in the southern hemisphere.

[a] Van Allen effect.

[b] Coriolis effect.

[c] Bayer-Hoffman effect.

[d] centripetal force effect.

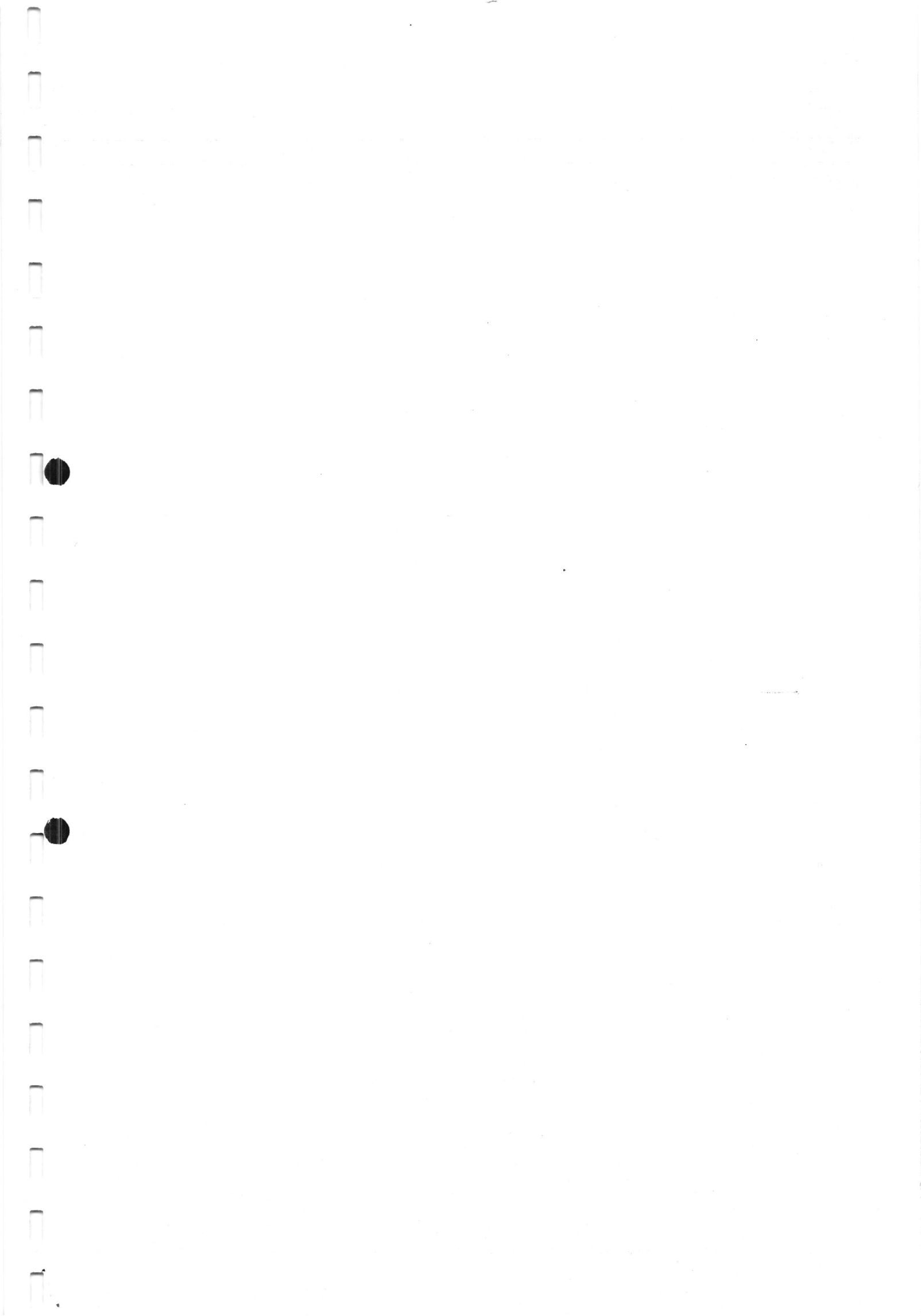
13. The moment of inertia tensor:

[a] is a tensor of the first rank.

[b] has only nine independent components.

[c] has only six independent components.

[d] is not symmetric.



SECTION "B"

[5Q × 4 = 20 marks]

1. Find the equation of motion of a bead sliding on a uniformly rotating wire in force-free space.
OR
Set up the Lagrangian and obtain Lagrange's equation for a compound pendulum. Deduce the formula for its time period.
2. A reference frame 'r' rotates with respect to inertial reference frame 's' with the (constant) angular velocity $\vec{\omega}$. If the radius vector, velocity and acceleration of a particle of mass m in frame 'r' are represented by \vec{r} , \vec{v}_r and \vec{a}_r respectively, show that the equation of motion in the inertial system is given by $\vec{F} - 2m(\vec{\omega} \times \vec{v}_r) - m\omega \times (\vec{\omega} \times \vec{r}) = m\vec{a}_r$.
3. State Kepler's laws of planetary motion. Prove that the radius vector sweeps out equal areas in equal times.
OR
Equation of the orbit of a particle under the action of central force is given by $r = a(1 + \cos\theta)$. Find the corresponding force.
4. Derive an expression for the angular momentum of a rigid body and hence define inertia tensor.
5. What is the Hamiltonian function? Derive the canonical equations of Hamilton.

SECTION "C"

[5Q × 7 = 35 marks]

6. Explain D'Alembert's principle. Obtain Lagrange's equation of motion for a conservative system using D'Alembert's principle.
7. Discuss the phenomenon of collision in one dimension between two particles when the collision is elastic in the laboratory frame as well as in the centre of mass frame.
OR
What is a collision? Explain briefly elastic and inelastic collision. A particle of mass m_1 suffers perfectly elastic collision with another particle of mass m_2 at rest in the laboratory frame of reference. After scattering m_1 and m_2 move at angles θ_1 and θ_2 with respect to the original direction of m_1 . Discuss the elastic collision between the two particles in the lab system. Show that in the lab system the particles of the same mass will be at right angles to each other after collision.
8. Derive the differential equation of an orbit in polar coordinates under central force. Show that if a particle describes a circular orbit under the influence of an attractive central force directed towards a point on the circle, then the force varies as the inverse-fifth power of the distance.

9. Obtain Euler's equations of motion for a rotating rigid body with a fixed point. From Euler's equations of motion for a rigid body, having no external torque about a fixed point, prove that $T = \frac{1}{2}I_1\omega_1^2 + \frac{1}{2}I_2\omega_2^2 + \frac{1}{2}I_3\omega_3^2 = \text{constant}$, where the terms have standard meaning.
10. What is Hamiltonian? Explain its physical significance. The Lagrangian for a system can be written as $L = ax^2 + b\frac{\dot{y}}{x} + cx\dot{y} + fy^2\dot{x}\dot{z} + g\dot{y}^2 - k\sqrt{x^2 + y^2}$, where a, b, c, f, g and k are constants. What is the Hamiltonian?

OR

What is cyclic coordinate? Prove that the generalized momentum conjugate to cyclic coordinate is conserved. A particle of mass m moves in a force field of potential V. Write (a) the Hamiltonian and (b) Hamilton's equations in spherical coordinates (r, θ, ϕ) .