M.Sc. Physics Assignment

Classical Mechanics
Batch: 2004-2026
The Cochin College

Maximum Marks: 100 **Time Allowed: Till 17/1/2025**

Instructions:

1. Answer **all** questions.
2. All questions carry **equal marks**.
3. Provide detailed solutions and derivations wherever applicable.
4. Diagrams must be neat and clearly labeled.

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1. Calculate the total scattering cross-section for hard-sphere scattering. Show the derivation clearly and discuss the physical implications of the result.
2. Calculate the moment of inertia and the principal moments of inertia of a box with masses M placed at each corner. Perform the calculation about an axis passing through one corner of the box along its edge. Clearly define the geometry of the box.
3. Discuss the trajectories of a particle moving under a central force field. Derive the relationship between energy and the trajectory. Consider a potential of the form $V(r) = -kr^n$ and explain how n affects the motion.
4. Derive the expression for the Coriolis force from first principles. Clearly state the assumptions and conditions under which the Coriolis force is observed.
5. A river flows in the northern hemisphere at a latitude of 30° from the equatorial plane. Calculate the Coriolis force acting on the river's flow. Discuss the direction and implications of this force on the river's trajectory.
6. Derive the differential equations governing the motion of a rigid body. Use the Euler angles to express the equations and explain their physical significance.
7. Differentiate between **Hamilton's Principal Function** and **Hamilton's Characteristic Function**. Provide examples to illustrate their uses in mechanics.
8. Draw a diagram of an ellipse representing the Earth-Moon system. Clearly mark the relevant points, including the positions of the Earth and Moon, foci, axes, angles, and the position vector of the Moon. Provide a brief explanation of each feature in the context of orbital mechanics.
9. Using the Lagrangian method, derive the relativistic equation of motion for a harmonic oscillator. Discuss the modifications introduced by relativistic effects.
10. Starting from the expression for angular momentum, derive the expression for the moment of inertia tensor. Provide a detailed explanation of its components and their significance in the rotational dynamics of rigid bodies.

End of Question Paper