MPH-006

ASSIGNMENT BOOKLET

M.Sc. (Physics) Programme
(MSCPH)

CLASSICAL MECHANICS II

Valid from 1st January, 2024 to 31st December, 2024

School of Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110068
(2024)

Dear Student,

Please read the section on assignments in the Programme Guide for M.Sc. (Physics). A weightage of 30 per cent, as you are aware, has been earmarked for continuous evaluation, **which would consist of one tutor-marked assignment** for this course. The assignment is in this booklet. The total marks for this assignment is 100, of which 40 marks are needed to pass it.

Instructions for Formatting Your Assignments

Before attempting the assignment please read the following instructions carefully:

1) On top of the first page of your answer sheet, please write the details exactly in the following format:

ENROLMENT NO.: ….…………………………………………

NAME: …………………………………………………

ADDRESS: ……………………………………………

COURSE CODE:…………………………..

COURSE TITLE: …………………………

ASSIGNMENT CODE: …………………..

STUDY CENTRE: ……………………….. **DATE:** …………………………………………

PLEASE FOLLOW THE ABOVE FORMAT STRICTLY TO FACILITATE EVALUATION AND TO AVOID DELAY.

2) Use only foolscap size writing paper (but not of very thin variety) for writing your answers.
3) Leave 4 cm margin on the left, top and bottom of your answer sheet.
4) Your answers should be precise.
5) **Submit the assignment answer sheets within the due date.**
6) The assignment answer sheets are to be submitted to your Study Centre as per the schedule. **Answer sheets received after the due date shall not be accepted. We strongly suggest that you retain a copy of your answer sheets.**
7) This assignment is **valid from 1st January, 2024 to 31st December, 2024**. If you have failed in this assignment or fail to submit it till its validity, then you need to get the assignment for the next year and submit it as per the instructions given in the Programme Guide.
8) For any queries, please contact: mbnewmai@ignou.ac.in, slamba@ignou.ac.in

We wish you good luck.

Tutor Marked Assignment
CLASSICAL MECHANICS II

Course Code: MPH-006
Assignment Code: MPH-006/TMA/2024
Max. Marks: 100

Note: Attempt all questions. The marks for each question are indicated against it.

PART A

1. a) Obtain the Lagrangian, the Hamiltonian and the equations of motion for a projectile near the surface of the earth. Take the mass of the projectile to be m and the z-axis as the upward vertical axis. (5)

   b) A particle of mass m has the Lagrangian:

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

   where $\mu = \dfrac{mM}{M+m}$.

   Determine the Routhian and the equation of motion. (5)

   c) The Lagrangian of a dynamical system is given as:

   $$L(q,\dot{q}) = \frac{\dot{q}^2}{25} - \frac{q^2}{16}$$

   Write the general solution for the Hamilton's equation and obtain the equation for the phase space curve for a set of initial conditions $q(t=0) = q_0, p(t=0) = p_0$. (5)

   d) For a given Lagrangian L, if the coordinate (q) is cyclic, then the system has translational symmetry under the transformation $q \rightarrow q + a$. Show that the momentum conjugate to q is conserved. (5)

   e) What is the Variational principle. Obtain Hamilton's equations from the Variational principle. (5)

2. a) Show that the transformation $Q = q^2$ and $P = \dfrac{p}{2q}$ is a canonical transformation by showing that it is an exact differential. Obtain the time independent generating function $F_2(q,P)$. (10)

   b) Using Poisson brackets, obtain the value of α and β for the given transformation:

   $$Q = q^\alpha \sin\beta p, P = q^\alpha \cos\beta p.$$

   Obtain the generating function $F_3(p,Q)$. (10)

   c) Show that the transformation $Q = q\sin\alpha - p\cos\alpha, P = q\cos\alpha + p\sin\alpha$ satisfies the symplectic condition for any value of the parameter α. (5)

PART B

3. a) Obtain the generating function $F_2(q,P)$ for the transformation:

$$Q = q\sin\alpha - p\cos\alpha, P = q\cos\alpha + p\sin\alpha \ . \qquad (5)$$

b) Write down the Lagrangian for a relativistic free particle. Show that the Hamilton's principal function is a Lorentz invariant. (5)

4. a) The Hamiltonian of a system is given as:

$$H = \frac{1}{2m}(p_r^2 + \frac{p_\theta^2}{r^2} + \frac{p_\phi^2}{r^2\sin^2\theta}) + a(r) + \frac{b(\theta)}{r^2}$$

where $a(r)$ and $b(\theta)$ are known constants.

Obtain the complete integral of Hamilton-Jacobi equation for the given system. (10)

b) For a particle moving in a central force field, the Hamiltonian of the system is given by:

$$H = \frac{1}{2m}(p_r^2 + \frac{p_\theta^2}{r^2}) - \frac{k}{r}.$$

Assuming the motion to be elliptical, obtain the action angle variables J_r and J_θ. (10)

5. a) Calculate the inertia tensor for the system of four points with masses 2 gm, 3 gm, 4 gm and 5 gm located at the points (1,1,0), (1,0,0), (1,1,1,), and (1,1,-1) cm. (5)

b) Obtain the degrees of freedom for a rigid body which has:

(i) one point fixed and (ii) two points fixed. (5)

c) Using appropriate labelled diagram, obtain the angular velocity of a heavy symmetrical top. (10)

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