

No. of Printed Pages : 10 **MPH-002/MPH-003**

M. SC. (PHYSICS) (MSCPH)

Term-End Examination

December, 2024

**Part-A : MPH-002 : CLASSICAL
MECHANICS—I**

AND

**Part-B : MPH-003 : ELECTROMAGNETIC
THEORY**

Time : 3 Hours

Maximum Marks : 50

Instructions :

- 1. Students registered for both MPH-002 and MPH-003 courses should answer both the question papers in two separate answer books entering their enrolment number, course code and course title clearly on both the answer books.*
 - 2. Students who have registered for any of the MPH-002 or MPH-003 should answer the relevant question paper after entering their enrolment number, course code and course title on the answer book.*
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Part-A**MPH-002 : CLASSICAL****MECHANICS—I**

Time : $1\frac{1}{2}$ Hours

Maximum Marks : 25

Note : *All questions are compulsory. However, internal choices are given. Marks for each question are indicated against it. You may use a calculator. Symbols have their usual meanings.*

1. Attempt any *one* part : $5 \times 1 = 5$

- (a) A particle of mass m travelling with speed u undergoes an elastic collision with a particle of mass $9m$ which is initially at rest. After the collision, the particle (m) is

deflected by 60° with respect to its initial direction of motion. Calculate the speed of the particle (m) after the collision in terms of u . 5

(b) State D' Alembert's principle. Using it, determine the equation of motion for an Atwood's machine with masses M and $2M$. 5

2. Attempt any *one* part : $5 \times 1 = 5$

(a) Consider a particle of mass m falling freely under gravity near the surface of the earth. Obtain Lagrange's equations of motion. 5

(b) Starting from $m\ddot{r} - \frac{l^2}{mr^3} = f(r)$, show that

the differential equation of an orbit for a particle of mass m in a central force is

$$\left[\frac{d^2u}{d\theta^2} + u \right] = -\frac{m}{l^2} \frac{d}{du} V\left(\frac{1}{u}\right), \text{ where } u = \frac{1}{r},$$

where $f(r)$ is the force as a function of r , l is the angular momentum. 5

3. Attempt any *one* part : 5×1=5

(a) Obtain the Lagrangian and Lagrange's equation of motion for a bead of mass m which slides without friction along a wire in the shape of a parabola $y = Ax^2$. 5

- (b) Determine the differential scattering cross-section and the total scattering cross-section of a particle of mass m , if it is scattered by a rigid sphere of radius A . 5

4. Attempt any *one* part : 10×1=10

- (a) (i) For a particle of mass m moving in a spiral orbit $r(\theta) = ke^{-2\theta}$, obtain the force law. 5

- (ii) Obtain the Lagrangian for small oscillations around a point of stable equilibrium ($q_0 = 0$). 5

- (b) Obtain the energy of a very weakly damped oscillator whose displacement at time t is

$$q(t) = a \cos(\omega_a t + \alpha) e^{-\frac{\lambda}{2}t},$$

where $\omega_a = \sqrt{\omega^2 - \frac{\lambda^2}{4}}$, ω is the natural frequency, $\lambda = \frac{b}{m}$ (b is the damping coefficient), a and α are some constants and m is the mass of the oscillator. 10

Part-B**MPH-003 : ELECTROMAGNETIC****THEORY**

Time : $1\frac{1}{2}$ Hours

Maximum Marks : 25

Note : *All questions are compulsory. Marks for each question are indicated against it. Symbols have their usual meanings. You can use calculator.*

1. Answer any *three* parts : 3×5=15

(a) An infinitely long uniformly charged cylinder of radius R has positive volume charge density ρ . Determine the electric field at a point inside the cylinder. 5

(b) Define electric polarization and explain the mechanism of polarization in polar and non-polar dielectrics. 2+3

- (c) Consider a spherical cavity of radius r inside a uniformly polarized dielectric of polarization $\vec{P}$. Show that the electric field at the centre of the cavity due to the bound charges on the surface of the cavity is given as :

5

$$\vec{E}_S = \frac{\vec{P}}{3\epsilon_0}$$

- (d) Calculate the magnetic vector potential inside a long solenoid with n turns per unit length of radius R and carrying a steady current I .
- (e) Derive the wave equation for electric field from Maxwell's equations in vacuum.

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2. Answer any *one* part : $1 \times 10 = 10$

- (a) State the conditions under which we can apply the method of images to determine electric potential. Two charges $+q$ and $+2q$ are placed at $(0, 0, d)$ and $(0, 0, 2d)$, respectively, near an earthed infinite conducting plate kept in the $x - y$ plane. Using the method of images, determine the electric potential of the system. Give appropriate diagram. Also, verify that the expression for electric potential satisfies the boundary condition : $2+4+2+2$

$$V = 0 \text{ at } z = 0.$$

- (b) Distinguish between diamagnetism and paramagnetism. Show that the effective induced magnetic moment produced in a diamagnetic material placed in a magnetic field is given by :

2+8

$$\left\langle \vec{\Delta m} \right\rangle = - \left(\frac{Ze^2}{6me} \right) \left\langle r^2 \right\rangle \vec{B}$$

Assume that the atomic orbit is circular.

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