No. of Printed Pages : 8 **MPH–002/MPH–003**

M. SC. (PHYSICS) (MSCPH)

Term-End Examination

June, 2024

Part–A MPH–002 : CLASSICAL MECHANICS—I

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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.*

P. T. O.

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 : 5×1=5

   (a) A block of mass m slides down a fixed inclined plane without friction. The inclined plane makes an angle θ with the horizontal. Calculate the acceleration of the block and its position as a function of time. 5

   (b) Write down the equations for the constraints for three point masses connected by rigid rods of length L. What are holonomic and non-holonomic constraints ? 3+2

2. Attempt any ***one*** part : 5×1=5

(a) A bead of mass m slides on a smooth rod which is rotating about one fixed end in a vertical plane with uniform angular velocity ω. Write the Lagrangian for the system and obtain the equation of motion. 5

(b) Consider a head-on collision between two masses m and $2m$ which are travelling in the same direction with velocities $\vec{u}_1$ and $\vec{u}_2$, respectively. If the kinetic energy of particle with mass $2m$ is half of the other particle before the collision, calculate the value of $\frac{u_1}{u_2}$ such that the particle with mass $2m$ will be at rest after collision. Also calculate $\frac{v_1}{u_1}$, if v_1 is the velocity of the particle with mass m after the collision. 5

3. Attempt any ***one*** part : 5×1=5

(a) (i) Write the mathematical expression for virial theorem of Clausius for periodic motion. 2

(ii) Using virial theorem, show that $2<\mathrm{T}>+<\mathrm{V}>=0$ for a particle moving in a central force field where $\mathrm{V}(r)=\mathrm{K}r^{-1}$.

3

(b) Show that the Laplace-Runge-Lenz vector is a conserved quantity for $f(r)=-\frac{k}{r^2}$ where $f(r)$ is the force as a function of distance and k is some constant. 5

4. Attempt any ***one*** part : 10×1=10

(a) (i) Consider a particle of mass m subjected to a force, $\mathrm{F}=m\mathrm{A}e^{-\frac{\lambda}{4}t}$. Obtain $q(t)$ using the initial conditions $q(0)=0$ and $\dot{q}(0)=0$. 5

(ii) A particle of mass m moves freely on the surface of a sphere of radius R. The Lagrangian for such a system is given as :

$$L = \frac{1}{2} mR^2 \left(\dot{\theta}^2 + \sin^2 \theta \dot{\phi}^2 \right)$$

Obtain the equations of motion. Show that p_ϕ is a constant of motion. 4+1

(b) Consider a double pendulum with masses m_1, m_2 and lengths l_1, l_2. Write down the V and T matrices for the system. 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.*

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1. Answer any ***three*** parts : 3×5=15

   (a) Use Gauss's law to determine the electric field due to a uniform infinite line charge carrying linear charge density λ. Give appropriate diagram. 4+1

   (b) Solve Poisson's equation to obtain the electric potential and electric field due to a line charge along the x-axis having constant charge per unit length for the following boundary conditions : 5

   $V(x) = 0$ at $x = 0$ and $V(x) = V_0$ at $x = L$

(c) Distinguish between polar and non-polar dielectrics. A dielectric block is polarized such that

$$\vec{P} = 2.2\times10^{-7}\left(x\hat{i} + 4\hat{j} + \hat{k}\right)\text{Cm}^{-2}$$

Calculate the bound volume charge density for the block. 2+3

(d) Show that the forque on a current loop placed in a uniform magnetic field is given by : 5

$$\vec{\tau} = \vec{m} \times \vec{B}$$

(e) What do you understand by domain of a ferromagnetic material ? Explain the processes through which domains in a ferromagnetic material change under the influence of external magnetic field. 5

2. Answer any *one* part : 1×10=10

(a) Using the multiple expansion technique, obtain an expression for electric potential due to a charge distribution at a far away point. 10

(b) Write the *four* fundamental laws of electricity and magnetism. Why are these laws called the fundamental laws ? State the symmetries in these laws. What are the asymmetries in the fundamental laws of electricity and magnetism ? 4+1+2+3