No. of Printed Pages : 11

MPH–002/MPH-003

M. SC. (PHYSICS) (MSCPH)
Term-End Examination
June, 2026

MPH-002 : CLASSICAL MECHANICS–I
&
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.*

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 : 1×5=5

(a) What is meant by conservative force ? Determine whether the force $\vec{F} = \frac{x\hat{i} + y\hat{j}}{x^2 + y^2}$ is conservative or not. 5

(b) Define holonomic and non-holonomic constraints. Using the motion of a double pendulum as an example, show the effect of constraints in terms of the number of dynamical degrees of freedom of the system. Clearly mark the equations of constraint. 5

2. Attempt any *one* part : 1×5=5

(a) Derive the Lagrangian and Euler-Lagrange equation for Atwood's machine consisting of two blocks of wood of masses m_1 and m_2, respectively, connected by an inextensible string of length L, assuming the radius of pulley to be zero. 5

(b) Starting from $m\ddot{r} - \frac{l^2}{mr^3} = f(r)$, show that the differential equation of an orbital for a particle of mass 'm' in a central force is 5

$$\left[\frac{d^2u}{d\theta^2}+u\right]=-\frac{m}{l^2}\frac{d}{du}v\left(\frac{1}{u}\right)$$

where $u=\frac{1}{r}$ and $f(r)$ is the force as a function of r, l is the angular momentum.

3. Attempt any *one part* : 1×5=5

(a) Obtain the Euler-Lagrange equations of motion for a spherical pendulum of mass M and length L_o. 5

(b) An electron of charge '– e' is moving around a nucleus of atomic number Z. If the trajectory of the electron is elliptical, find the time period (T). 5

4. Attempt any *one* part : 1×10=10

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

(ii) Distinguish under-damped, critically damped and over-damped oscillatory motion. 5

(b) (i) Consider two identical simple pendulums with each bob of mass 0.2 kg and length 0·5 m, connected to a spring to form a compound pendulum. If the spring constant is 3 Nm^{-1}, calculate the time periods of the two normal modes of the system. 5

(ii) Describe the physical meaning of the differential equation 5

$$\ddot{q} + \omega^2 q = f_0 \sin \omega_0 t$$

Solve the equation to obtain the equation of motion.

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 may use a calculator.*

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1. Answer any *three* parts : 3×5=15

   (a) A Gaussian surface for a cylindrical charge distribution has radius 2.0 m and height 50 m. Assuming that the electric field due to these charges is normal to the Gaussian surface and has magnitude 1000 NC^{-1}, calculate the volume charge density of the charge distribution. 5

(b) Solve Poisson equation for a p-n junction of width 'd' for which the volume charge density is given by

$$\rho = 2\rho_0 \operatorname{sech}\left(\frac{x}{d}\right)\tanh\left(\frac{x}{d}\right)$$

where $\rho_0 = eN_A = eN_D$ with N_A and N_D are the number of acceptor and donor atoms, respectively in the 'p' and 'n' sides near the junction. 5

(c) A thin dielectric rod of cross-section A extends along x-axis from $x = 0$ to $x = L$. The polarization of the rod is along its length and is given by $\vec{P} = (ax^2 + b)\hat{i}$. Obtain the bound volume charge density and surface charge densities at each end of the rod. 5

(d) A uniformly charged disk having charge 'q' and radius 'r' is rotating with constant angular velocity of magnitude 2ω. Obtain an expression for the dipole moment. 5

(e) Calculate the magnetizing field $\vec{H}$ and magnetic flux density $\vec{B}$ at : 5

(i) a point 105 mm from a long straight wire carrying a current of 10 A.

(ii) the centre of a 1000 turn solenoid which is 0·24 m long and bears a current of 1·5 A. Take : $\mu_0 = 4\pi \times 10^{-7}\ \text{Hm}^{-1}$.

2. Answer any *one* part : 1×10=10

(a) Consider two semi-infinite, grounded, conducting planes that cover the *y*-*z* and *x*-*z* planes and intersect each other along the *z*-axis that points outwards of that plane of the paper which is the *x*-*y* plane. A positive charge + Q is located at a point $\left(L_1, L_2\right)$ in the region between the planes. Using the method of images

(i) write down the boundary conditions on the potential V, and

(ii) deduce an expression for the electric potential V due to charge + Q. 10

(b) Write down Maxwell's equations for propagation of electromagnetic waves in vacuum. Deduce the conditions, when the following time varying electric and magnetic field satisfy Maxwell' equations :

$$\vec{E} = \hat{j}\, E_0 \cos(z - vt)$$

$$\vec{B} = -\hat{i}\, B_0 \cos(z - vt)$$

where E_0 and B_0 are constants. 10

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