2026

PHYSICS

(Major)

Anandaram Dhekial Phookan College Library
ACC. NO.
Date
Nagaon : Assam

Paper : PHY40200104MJ

(Mathematical Physics & Electricity and Magnetism)

Full Marks : 45

Time : 2 hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×5=5

(a) What is the order and degree of the following differential equation?

$$x^2\left(\frac{d^2y}{dx^2}\right)^3 + y\left(\frac{dy}{dx}\right)^4 + y^4 = 0$$

(b) Define a Hermitian matrix.

(c) The solid angle subtended at a point at the centre of a closed sphere is

(i) zero

(ii) π

(iii) 2π

(iv) 4π

(d) Calculate the work done in carrying 1C charge in a circular path around a charge of 10C.

(e) The dimensions of atomic polarizability α are those of

(i) Capacitance

(ii) Electric field intensity

(iii) Volume

(iv) Dipole moment

2. Answer any *five* questions : 2×5=10

(a) Solve : $y'' + 2y' + 5y = 0$

(b) Show that the functions $e^{ax}\sin bx$, $e^{ax}\cos bx$ are linearly independent with the help of Wronskian.

(c) Determine whether the following PDE is elliptic, parabolic, or hyperbolic :

$$2\frac{\partial^2 u}{\partial x^2} + 5\frac{\partial^2 u}{\partial x \partial y} + 2\frac{\partial^2 u}{\partial y^2}$$

(d) Find the rank of the matrix

$$A = \begin{bmatrix} 2 & 1 & -1 \\ 0 & 3 & -2 \\ 2 & 4 & -3 \end{bmatrix}$$

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(e) Is electric flux a scalar or vector? What is its SI unit? 1+1=2

(f) Obtain the expression of potential energy for a system of 4 charges.

(g) Can a parallel plate air capacitor of 1 farad having plate separation of 1 mm be constructed in the laboratory?

(h) An electron is moving in a field of magnetic induction of 0.5 W/m^2 with a velocity of 3×10^7 m/s along a circle. Find the radius of the circle and energy due to motion.

(i) Define the term Relative permeability and Magnetic susceptibility.

(j) Obtain the average value of alternating current during half cycle.

3. Answer any *four* questions : 5×4=20

(a) Derive the Newton's law of cooling by applying solution of first order ordinary differential equation.

(b) Solve : $(D^2 - 4D + 3)y = x^3$

(c) Determine whether the matrix $A=\begin{bmatrix}1 & 4\\ 2 & 3\end{bmatrix}$ is diagonalizable. If it is diagonalizable, then find the non-singular invertible matrix P and the diagonal matrix D such that $A=PDP^{-1}$. 1+4=5

(d) Using Gauss's law, find the electric field intensity due to a uniform infinite cylindrical charge distribution at a point *(i)* inside *(ii)* outside and *(iii)* on the surface of charge distribution.

(e) Define electric displacement vector $\vec{D}$ and polarization $\vec{P}$. Derive the relations $\vec{D}=\varepsilon_0\vec{E}+\vec{P}$ and $K=1+\chi_e$ where symbols have their usual meanings. 2 + 3

(f) What is capacitance? Obtain the capacitance of a cylindrical capacitor filled with dielectric. 1+4=5

(g) State Biot-Savart's law. A long wire carries a current of 2 A. An electron travels with a velocity of 4×10^4 m/s parallel to the wire, 0.1 m from it in a direction opposite to the current. What force does the magnetic field exert on the moving electron? 2 + 3=5

(h) Write a short note on any *one* of the followings :

(i) Ampere's circuital law and its applications

(ii) BH curve and hysteresis loss

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4. Answer any *one* questions : 10

(a) A body falling under gravity encounters resistance of the atmosphere. If the resistance varies as the velocity; show that the equation of motion is governed by

$$\frac{du}{dt}=g-ku$$

where u is the velocity, k is a constant and g is the acceleration due to gravity. Show that as t increases, u approaches the value of g/k. Also, if $u=\frac{dx}{dt}$, where x is the distance fallen by the body from rest in time t, show that

$$x=\frac{gt}{k}-\frac{g}{k^2}(1-e^{-kt})$$ 2+3+5=10

(b) (i) State the necessary and sufficient condition for a square matrix to possess an inverse. If $A=\frac{1}{9}\begin{bmatrix}-8 & 1 & 4\\ 4 & 4 & 7\\ 1 & -8 & 4\end{bmatrix}$, prove that $A^{-1}=A^{T}$, A^{T} being the transpose of A. 5

(ii) State the Cayley-Hamilton theorem. The matrix A is defined as, $A=\begin{bmatrix}1 & 2 & -3\\ 0 & 3 & 2\\ 0 & 0 & -2\end{bmatrix}$. Find the eigenvalues of $3A^3+5A^2-6A+2I$. 5

(c) (i) Obtain the expression for electric potential energy of a charged sphere. 5

(ii) What will happen to an electric dipole placed in a non-uniform electric field? An electric dipole of length 2 cm is placed with its axis making an angle 30° to a uniform electric field of 10^5 *N/C*. If it experiences a torque of $10\sqrt{3}$ Nm, calculate *(i)* the magnitude of charge on the dipole and *(ii)* potential energy of dipole. 1+2½+1½=5

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(d) (i) What is resonance in series *RLC* circuit? Obtain the frequency of resonance. Show that in series *RLC* circuit the band width is given by $f_2-f_1=\frac{R}{2\pi L}$. 1+2+5=8

(ii) State Thevenin theorem. 2

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