2026

PHYSICS

(Minor)

Paper : PHY4200104MN

Anandaram Dhekial Phookan College Library * Acc. No. Date Nagaon : Assam *

(Mathematical Physics & Electricity and Magnetism)

Time : 2 hours

Full Marks : 45

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?

$$\frac{d^2y}{dx^2} + a^2x = 0$$

(b) What is the necessary and sufficient condition for a matrix A to be Hermitian?

(c) Two charges $2\mu C$ and $4\mu C$ are separated by a distance of 10 cm. The ratio of force acting on the respective charges is

(i) 2 : 5
(ii) 5 : 2
(iii) 1 : 1
(iv) 4 : 16

(d) The potential is constant in certain region of space. The value of $\vec{E}$ in that region is

(i) zero
(ii) finite
(iii) infinite
(iv) None of the above

(e) What is the value of internal resistance of an ideal current source?

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

(a) Solve $y'' - 7y' + 12y = 0$.

(b) If $y_1(x) = e^x$, $y_2(x) = e^{-2x}$, show that they are linearly independent with the help of Wronskian.

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

$$\frac{\partial^2 u}{\partial x^2}+4\frac{\partial^2 u}{\partial x \partial y}+3\frac{\partial^2 u}{\partial y^2}$$

(d) Find the rank of the matrix

$$A=\begin{bmatrix} 3 & 2 & -1 \\ 0 & 3 & 4 \\ 5 & 1 & 2 \end{bmatrix}$$

(e) Write down the Laplace's equation in 3D. What is its significance? 1+1=2

(f) Calculate the electric potential at the surface of a gold nucleus. Given the radius of the nucleus $= 6\cdot 6\times 10^{-15}$ m, atomic number of gold is 79.

(g) Obtain the differential form of Gauss's law in dielectrics.

(h) The electric susceptibility of a material is $35\cdot 4\times 10^{-12} C^2/(Nm^2)$. What is the value of dielectric constant and permittivity of the material?

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(i) State Ampere's circuital law.

(j) Define magnetic intensity $(\vec{H})$ and magnetization vector $(\vec{M})$.

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

(a) Derive the law of radioactive decay for a nucleus by applying solution of first-order ordinary differential equation.

(b) Solve : $(D^2-2D+1)y=x^2e^{3x}$.

(c) What is the condition for a matrix to be diagonalizable? Determine whether the matrix $A=\begin{bmatrix} -2 & 0 & 0 \\ -1 & 3 & 3 \\ 6 & -6 & -6 \end{bmatrix}$ is diagonalisable. 1+4=5

(d) Using Gauss's law, find the electric field intensity due to a uniformly charged sphere at a point *(i)* inside *(ii)* outside and *(iii)* on the surface of the sphere.

(e) Explain the principle of a capacitor. Derive an expression for the capacitance of a parallel-plate capacitor with dielectric slab between the plates. 2+3=5

(f) Using Biot-Savart law, find the magnetic field due to an infinitely long wire carrying current I at a distance r from it.

(g) Define vector potential and hence derive an expression for the vector potential.

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

(i) BH curve and hysteresis loss

(ii) Thevenin and Norton theorem

4. Answer any *one* question : 10

(a) Consider the motion of a mass m, attached to a spring with spring constant k. Determine the time period of the simple harmonic motion executed by the mass.

(b) (i) Define inverse of a matrix. Find the inverse of the matrix,

$$A = \begin{bmatrix} 3 & -3 & 4 \\ 2 & -3 & 4 \\ 0 & -1 & 1 \end{bmatrix}$$ 5

(ii) State the Cayley-Hamilton theorem. Find the Eigenvalues of the matrix :

$$A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 0 & 0 & 1 \end{bmatrix}$$ 5

(c) (i) Calculate the potential and field due to a short dipole of dipole moment 2×10^{-27} C-m at a point distant 2 cm from it (1) on its axis and (2) on its perpendicular bisector. 2½+2½=5

(ii) A long straight metal wire of a circular cross-section of radius r carries a steady current I, uniformly distributed over its cross-section. Find the magnetic field inside $x < r$ as well as outside $x > r$ the wire. Also plot the graph between the strength of magnetic field B and the distance in each case. 3+2=5

(d) (i) What is resonance in parallel LCR circuit? Obtain the frequency of resonance. 1+4=5

(ii) A series LCR circuit with L = 0.12 H, C = 480 nF, R = 23 ohm connected to a 230 volt variable frequency supply.

1. What is the source frequency for which current amplitude is maximum? Obtain this maximum value of current. 2
2. Obtain the impedance of the circuit at resonance. 1
3. Obtain the value of maximum average power absorbed by the circuit. 1
4. Find the Q-factor of the circuit. 1

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