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1 (Sem-2/FYUGP) PHY 21 MJ

2026

PHYSICS

(Major)

Paper : PHY4200104MJ

**(Mathematical Physics and 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 : $1 \times 5 = 5$

- (a) Write the Laplace equation in three dimension.
- (b) What does it mean by the rank of a matrix ?
- (c) Two conducting spheres of same radii, one solid and the other hollow are charged to same potential. Which one will hold more charge ? Give reason.
- (d) Define a Bilateral circuit.
- (e) Give *one* example of ferromagnetic material.

2. Answer **any five** of the following questions : $2 \times 5 = 10$

- (a) Find the degree of the following differential equation

$$\left(\frac{d^3 y}{dx^3} \right)^{2/3} + 4 - 3 \frac{d^2 y}{dx^2} + 5 \frac{dy}{dx} = 0$$

(b) What are the eigenvalues of the matrix

$$\sigma_3 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} ?$$

✓(c) What are the *two* necessary conditions for applying Gauss's Law to find electric field intensity due to a charge distribution?

(d) Calculate the electric flux originating from a charge of 10C. Given

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-1}.$$

✓(e) Define dielectric constant of a medium. What is its value for vacuum?

✓(f) Distinguish between polar and non-polar dielectric.

✓(g) State the Biot-Savart's law.

(h) What information can be drawn from hysteresis loop ?

(i) Draw the phasor diagram for series LCR circuit.

(j) A coil of inductance 10mH and resistance 10Ω is connected in parallel with a condenser of capacity $0.1\mu\text{F}$. Find the impedance of the circuit at resonance.

3. Answer **any four** of the following questions :

$5 \times 4 = 20$

(a) Test whether

$$\left(\frac{1}{y} - \frac{2}{x}\right) dx + \left(-\frac{x}{y^2} + \frac{3}{y}\right) dy = 0$$

is an exact equation and find its solution accordingly.

(b) Show that sum of two Hermitian matrices is a Hermitian matrix.

✓(c) Establish the Coulomb's law from Gauss's law.

(d) Two point charges carrying $15\mu\text{C}$ and $2.5\mu\text{C}$ amount of charges are located 30cm apart. Find the potential at the mid point of the line joining the two charges.

✓(e) Discuss the phenomenon of polarization in dielectrics.

✓(f) Express the Ampere's circuital law in differential form.

(g) A magnetizing field of 800Am^{-1} produces a magnetic flux of 4.8×10^{-5} weber in a bar of iron of cross-section 0.1cm^2 . Calculate the magnetic permeability and magnetic susceptibility of the bar.

$$3+2=5$$

✓ (n) Define Q-factor of an oscillatory circuit. What is its dimension? Write the relation between Q-factor and band width.

4. Answer **any one** of the following questions :

(a) A spring for which spring constant $K = 400 \text{ Nm}^{-1}$ hangs in a vertical position with its upper end fixed to a support.

A mass of 20 kg is attached to the lower end and the system brought to rest.

Find the position of the mass at time t , if a force of $(40 \sin 4t) \text{ N}$ is applied to the support.

(b) Find the electric field intensity at a point lying outside a uniformly charged

(c) What is a dielectric ? Derive the relation between dielectric constant and susceptibility. $2+8=10$

(d) Obtain the condition of resonance in parallel LCR circuit.
