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B.Sc./3rd Sem/PHS/25(NEP)

2025

3rd Semester Examination (CCFUP : NEP)

PHYSICS

Paper : MJ 4-T (Single Core Major)

(Electromagnetic Theory with
Mathematical Methods - II)

Full Marks : 60

Time : Three Hours

The figures in the margin indicate full marks.

*Candidates are required to give their answers
in their own words as far as practicable.*

Group - A

Answer any *ten* questions : $2 \times 10 = 20$

1. Show that $(AB)^T = B^T A^T$ where T refers to transpose of a matrix.
2. A six sided die is rolled twice. What is the probability that the sum of the numbers is at least 10?
3. An unpolarized plane light wave of intensity 20 mW/cm^2 passes through two Nicols with their principal sections at 30° to each other. Find the intensity of the transmitted wave.

P.T.O.



4. Show that $\beta\left(\frac{1}{2}, \frac{1}{2}\right) = \pi$.
5. While $\langle \psi | \psi \rangle$ represents a number, what does the object $|\psi\rangle\langle\psi|$ represent?
6. Check whether the matrix $\begin{bmatrix} 0 & 1+i \\ -1+i & 0 \end{bmatrix}$ is Hermitian or not.
7. A coil of 100 turns is pulled in 0.04 sec from between the poles of a magnet where its area includes a flux of 4×10^{-5} Wb. Calculate the emf induced in the coil.
8. Find the percentage of light reflected when light is incident normally at a water-glass interface. Refractive indices of water and glass are respectively $4/3$ and $3/2$.
9. Write the function of a quarter-wave plate.
10. Why is a series LCR circuit called a band-pass filter? Explain.
11. Find A^5 for $A = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{bmatrix}$.
12. What is radiation pressure? Explain.
13. What is Brewster's angle of polarization for reflection of light from air to glass medium ($n_g = 1.65$)?

(3)

14. Suppose a microwave experiment is designed to operate at a frequency of 10^{10} Hz. How thick would you make the silver coatings? Resistivity of silver $\rho = 1.59 \times 10^{-8}$ ohm-meters.
15. Explain the Biot's law of rotatory polarization.

Group - B

Answer any *four* questions : $5 \times 4 = 20$

16. State and prove Bayes' theorem. $2+3$
17. Find the eigenvalues and eigenvectors of the matrix

$$\begin{pmatrix} 3 & 1 & 4 \\ 0 & 2 & 6 \\ 0 & 0 & 5 \end{pmatrix}. \quad 2+3$$

18. Show that field vectors $\vec{E}$ and $\vec{H}$ are mutually perpendicular and also perpendicular to the direction of propagation of the electromagnetic wave.
19. (a) Using the properties of the Beta function, show that :

$$\sqrt{n} \sqrt{1-n} = \frac{\pi}{\sin(n\pi)} (0 < n < 1)$$

- (b) Show that, the eigenvalues of a Hermitian matrix are always real. $3+2$

P.T.O.

(4)

20. If ϕ and ψ are any two vectors in an inner product space V over the field F , then show that $|\langle \phi, \psi \rangle| \leq \|\phi\| \cdot \|\psi\|$.
21. Explain how elliptically polarized light can be produced experimentally.

Group - C

Answer any *two* questions : $10 \times 2 = 20$

22. (a) Derive an expression for induced emf in a conductor of length ' l ' moving with velocity $\vec{v}$ in a direction perpendicular both to its length and to uniform magnetic field $\vec{B}$.
- (b) Show that the coefficient of self-induction of a circuit is equal to twice the work required to establish unit current in circuit.
- (c) Find the mutual inductance between two parallel co-axial circular coils of radii R_1 and R_2 consisting of N_1 and N_2 turns, respectively. What will be value of the mutual inductance if $R_2 \gg R_1$?
- $3+2+(4+1)$
23. (a) State and explain Cayley-Hamilton theorem.
- (b) Find the characteristic equation and verify the Cayley-Hamilton theorem for the following matrix

$$\begin{pmatrix} 1 & 2 & 3 \\ 2 & -1 & 4 \\ 3 & 1 & 1 \end{pmatrix}.$$

$3+(3+4)$

24. (a) Apply the Gram-Schmidt orthogonalization process to find an orthogonal basis and then an orthogonal basis for the subspace U of $\mathbb{R}^4$ spanned by

$$v_1 = (1, 1, 1, 1), v_2 = (1, 2, 4, 5), v_3 = (1, -3, -4, -2).$$

- (b) There are three polaroids A , B and C . The polaroids A and C are crossed and the polaroid B is placed between A and C . Find the angle between the planes of transmission of A and B such that intensity of light emerging from the polaroid C is maximum.

6+4

25. (a) State and prove the Poynting theorem.
- (b) Calculate the magnitude of the Poynting vector for a 100 watt lamp at a distance of 0.25 m from the lamp.

(2+5)+3
