2015

PHYSICS

Paper : 104 (Old Course)

ELECTRODYNAMICS

Full Marks : 80

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer all: 1 × 6 = 6

1. If magnetic monopoles did exist, how many of Maxwell's equations would have to be changed?

   (a) One (b) Two (c) Three (d) None

2. What does a changing electric field induce?

   (a) Charges (b) Magnetic filed (c) Electrons

   (d) None of them.

3. The electric field for a plane electromagnetic wave travelling

(1) *P.T.O.*

in the positive z direction is represented by which one of the following:

(a) $\hat{k}_1 E_0 e^{i(kz-\omega t+\varphi)}$

(b) $i_1 E_0 e^{i(kz-\omega t+\varphi)}$

(c) $\hat{i}_1 E_0 e^{i(kz-\omega t+\varphi)}$

(d) $\hat{k}_1 E_0 e^{i(kz-\omega t+\varphi)}$

where $\hat{i}_1$ and $\hat{k}_1$ are the unit vectors along x and z directions.

4. Transverse magnetic (TM) modes have –

(a) magnetic field in the direction of propagation.

(b) no magnetic filed in the direction of propagation.

(c) electric field in the direction of propagation.

(d) both electric field and magnetic field in the direction of propagation.

5. Which one of the following is not Maxwell's equation?

(a) $\nabla.D = \rho$ (b) $\nabla \times E = -\dfrac{\partial B}{\partial t}$ (c) $\nabla \times H = J + \dfrac{dD}{dt}$

(d) $\nabla.J = -\dfrac{d\rho}{dt}$

6. Which of the following matching is incorrect.

(a) Amperes circuital law, $\nabla \times H = J + \dfrac{dD}{dt}$

(b) Displacement current density, $J = \dfrac{dD}{dt}$

(c) Poisson equation, $\nabla^2 V = 0$

(d) Continuity equation, $\nabla.J = -\dfrac{d\rho}{dt}$

Answer all: $2 \times 6 = 12$

7. State first uniqueness theorem and hence prove it. 2

8. Explain why plasma is diamagnetic. 2

9. Give the condition for Transverse Magnetic (TM) mode in a waveguide. 2

10. What are Greens first and second identity / theorem? 2

11. What is anomalous dispersion? 2

12. What is $\overrightarrow{(E \times B)}$ drift? 2

Answer all: $5 \times 4 = 20$

13. On the basis of Maxwell's equation show that the co-efficient of reflection R at the surface of glass of index of refraction n for e. m. waves at normal incidence is

$$R = (n-1)^2 / (n+1)^2$$ 5

14. Show that under Lorentz gauge Maxwell's equations are equivalent to the inhomogeneous equations

$$\nabla^2 \Phi - \frac{1}{c^2}\frac{\partial^2 \Phi}{\partial t^2} = -\frac{\rho}{\varepsilon_0}$$ 5

$$\nabla^2 A - \frac{1}{c^2}\frac{\partial^2 A}{\partial t^2} = -\mu_0 J.$$

15. Explain the term waveguides. Categorize the modes of waveguides and hence give their conditions. 5

16. Show that the magnetic moment of a charged particle in magnetic field with a gradient parallel to its direction is a constant of motion. 5

Answer any two from the following: $9 \times 2 = 18$

17. Consider the TE waves in a rectangular waveguide with perfectly conducting walls and then deduce the expression for cutoff frequency of the waveguide. 9

18. Expalin Skin depth and hence give mathematical expression. 4

Show that electrons in plasma execute standing oscillations with a characteristic frequency of

$$(N_0 e^2 / m_e \varepsilon_0)^{1/2}$$ 5

19. Explain Debye shielding and Debye length. Find an expression for Debye length. $2 + 2 + 5 = 9$

Answer any two questions out of four: $12 \times 2 = 24$

20. An electromagnetic wave travelling in a dielectric medium is incident on another dielectric medium, the incident wave being polarized normal to the plane of incidence. Now obtain the Fresnel's equation. $3 + 9 = 12$

21. (a) What is convective derivative? Express mathematically. 3

(b) Derive a dispersion relation for two stream instability and show that for sufficiently lower streaming, velocity waves are unstable. 7

(c) What is the role of Landau-damping? 2

22. (a) Consider an electromagnetic waves propagating in z-directions, so that E and B vary only in the direction of z-axis. Show that both vectors E and B are perpendicular to each other. 7

(b) Show that the propagation vector k for electromagnetic waves in a conducting medium is complex. 5

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