2014

(6th Semester)

PHYSICS

ELEVENTH PAPER

(Electromagnetic Theory)

Full Marks : 55

Time : 2 hours

(PART : B—DESCRIPTIVE)

(*Marks* : 35)

The figures in the margin indicate full marks for the questions

1. *(a)* State and explain Faraday's laws of electromagnetic induction in integral and differential forms.

(b) Discuss the concept of displacement current and explain how modifications are made with Ampere's law. 2+2=4

Or

(a) Derive Maxwell's equation $\vec{\nabla} \cdot D = 4\pi\rho$ where D is electric displacement and ρ is the charge density. 3

(b) Using Maxwell's equation, discuss the boundary conditions for electric field vector at the interface between different media. 4

2. (a) Show that the electromagnetic wave equation is satisfied by electric field and magnetic field in free space, and hence explain the intrinsic impedance of the medium in which the wave propagates. 3+1=4

(b) Show that the plane electromagnetic waves are wholly transverse in nature. 3

Or

Define the Poynting theorem and express them in differential form and hence deduce necessary equation representing the Poynting vector. 2+5=7

3. Discuss the reflection and refraction of electromagnetic wave by considering the oblique incidence at the boundary. 7

Or

Using Maxwell's equation, show that the propagation of electromagnetic wave in conducting medium is damped.

(Continued)

4. What are the electromagnetic potentials? Applying Lorentz condition, show that the electromagnetic potentials satisfy the electromagnetic wave equations. 7

Or

Discuss the transformation of electromagnetic wave by using Coulomb gauge transformation. Show that the scalar potential satisfies the Poisson's equation and hence explain the origin of the transverse gauge.

5. Deduce the total power radiated from an oscillating dipole

$$\langle P_E \rangle = \frac{1}{4\pi\varepsilon_0}\left(\frac{p_0^2\omega^4}{3c^2}\right)$$

where p_0 is the amplitude of electric dipole, ω is the frequency of oscillating dipole and c is the velocity of light. 7

Or

What are waveguides? Show that the phase velocity of the waveguides is infinite exactly at cutoff modes. 2+5=7

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(PART : A—OBJECTIVE)

(*Marks* : 20)

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SECTION—A

(*Marks* : 5)

Put a Tick ☑ mark against the correct answer in the box provided : 1×5=5

1. Which one of the following Maxwell's equations is originated from Gauss' law applied to electrostatic?

(a) $\vec{\nabla} \cdot D = 4\pi\rho$ ☐

(b) $\vec{\nabla} \cdot B = 0$ ☐

(c) $\vec{\nabla} \times E = -\frac{1}{c}\frac{\partial B}{\partial t}$ ☐

(d) $\vec{\nabla} \times H = -\frac{4\pi}{c} J + \frac{1}{c}\frac{\partial D}{\partial t}$ ☐

2. When unpolarized light is incident on the surface of dielectric medium at Brewster's angle

(a) the reflected light is plane polarized and the angle between reflected and refracted is 90° ☐

(b) the reflected light is unpolarized and the angle between reflected and refracted is 60° ☐

(c) the reflected light is plane polarized and the angle between reflected and refracted is 45° ☐

(d) the reflected light is partly polarized and the angle between reflected and refracted is 30° ☐

3. If E and B are monochromatic waves of frequency travelling in the radial direction at the speed of light, the ratio of their amplitudes is

(a) $\frac{1}{\sqrt{\varepsilon_0 \mu_0}}$ ☐

(b) $\frac{1}{\varepsilon_0 \mu_0}$ ☐

(c) $\varepsilon_0 \mu_0$ ☐

(d) $\sqrt{\varepsilon_0 \mu_0}$ ☐

4. If n and m are real quantities called the optical constant of the medium, the complex refractive index of the medium is given by

(a) $\frac{1}{\sqrt{n+im}}$ ☐

(b) $\frac{1}{n+im}$ ☐

(c) $n+im$ ☐

(d) $\sqrt{n+im}$ ☐

5. In a propagation of TE waves in a rectangular waveguide with inner dimensions a and b, the wave equation will be

(a) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\gamma\right)\psi=0$ ☐

(b) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{1}{\gamma}\right)\psi=0$ ☐

(c) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{1}{\gamma^2}\right)\psi=0$ ☐

(d) $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\gamma^2\right)\psi=0$ ☐

SECTION—B

(*Marks* : 15)

Give very short answers to the following questions : $3 \times 5 = 15$

1. Starting from Maxwell's equations, show that the electric field satisfies the following differential equation in a homogeneous medium containing charges and currents :

$$\nabla^2 E - \mu\varepsilon \frac{\partial^2 E}{\partial t^2} = \frac{1}{\varepsilon} \nabla\rho + \mu \frac{\partial J}{\partial t} \ .$$

Where the notations in the equation have their usual meanings.

2. Define the radiation pressure and give the relation with intensity of e m wave

2. Define the radiation pressure and give the relation with intensity of e.m. wave.

3. Explain in brief the skin depth and the skin effect in electromagnetic waves.

4. Define electromagnetic field momentum per unit time.

8. Give the definition of retarded potential and retarded time

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