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(CBCS)

(6th Semester)

PHYSICS

FIFTEENTH PAPER

(Electromagnetic Theory)

Full Marks : 75

Time : 3 hours

The figures in the margin indicate full marks for the questions

(PART : A—OBJECTIVE)

(*Marks* : 10)

Put a Tick (✓) mark against the correct answer in the brackets provided : 1×10=10

1. The direction of the induced e.m.f. in a circuit is given by

(a) Faraday's law ( )

(b) Fleming's left-hand rule ( )

(c) Lenz's law ( )

(d) Ampere's law ( )

2. Magnetic fields between the parallel plates of a capacitor are due to

(a) displacement current ( )

(b) conduction current ( )

(c) both conduction and displacement current ( )

(d) neither conduction nor displacement current ( )

3. Which of the following has coulomb as the unit?

(a) $\circ \vec{H}\ dl$ ( )

(b) $\circ \vec{E}\ dl$ ( )

(c) $\circ \vec{D}\ ds$ ( )

(d) $\circ \vec{E}\ ds$ ( )

4. During the propagation of electromagnetic waves in a medium

(a) electric energy density is double of the magnetic energy density ( )

(b) electric energy density is half of the magnetic energy density ( )

(c) both electric and magnetic energy densities are equal ( )

(d) both electric and magnetic energy densities are zero ( )

5. The magnitude of impedance in a conducting medium to electromagnetic wave is

(a) $Z_0 \sqrt{\frac{\quad}{\quad}}$ ( )

(b) $Z_0 \sqrt{\frac{\quad}{\quad}}$ ( )

(c) $Z_0 \sqrt{\frac{\quad}{\quad}}$ ( )

(d) $Z_0 \sqrt{\frac{\quad}{\quad}}$ ( )

6. In a conductor, the phase difference between displacement and conduction current is

(a) $\frac{}{4}$ ( )

(b) $\frac{}{2}$ ( )

(c) ( )

(d) zero ( )

7. Given the vector potential is $16\hat{i}$ $12\sin y\hat{j}$. The field intensity at the origin is

(a) 12 ( )

(b) 16 ( )

(c) 28 ( )

(d) 4 ( )

8. The gauge is known as Lorentz's gauge when the magnetic vector and scalar potentials satisfy the condition

(a) $\text{div}\vec{B}$ $\frac{B}{t}$ 0 ( ) *(b)* $\text{div}\vec{A}$ $\frac{}{t}$ 0 ( )

(c) $\text{div}\vec{D}$ $\frac{}{t}$ 0 ( ) *(d)* $\text{div}\vec{H}$ $\frac{H}{t}$ 0 ( )

9. Stefan-Boltzmann law states that the energy radiated per unit area, per unit time by the blackbody is

(a) directly proportional to the square of the temperature ( )

(b) inversely proportional to the square of the temperature ( )

(c) directly proportional to the fourth power of the temperature ( )

(d) inversely proportional to the fourth power of the temperature ( )

10. At thermal equilibrium, the number of atoms (population) at each energy level

(a) always remains the same ( )

(b) decreases as the energy level increases ( )

(c) increases as the energy level increases ( )

(d) None of the above ( )

(SECTION : B—SHORT ANSWER)

(*Marks* : 15)

Answer the following questions : 3×5=15

UNIT—I

1. Show that Ampere's law for varying currents may be written as $\oint \vec{B}\ dl = \mu_0 I + \mu_0 \varepsilon_0 \frac{\vec{E}}{t}$, where the symbols have their usual meanings.

OR

2. Deduce the differential form of Faraday's law of electromagnetic induction.

UNIT—II

3. Show that electromagnetic waves are transverse in nature.

OR

4. Write down the first steady-state Maxwell's equation and write its physical significance.

UNIT—III

5. Explain skin depth of a conductor in case of electromagnetic wave.

OR

6. Find out the expression for reflection and transmission coefficients of electromagnetic wave in terms of the refractive indices of two media.

UNIT—IV

7. What do you mean by magnetic scalar potential?

OR

8. Deduce an equation for Lorentz gauge.

UNIT—V

9. State and prove Kirchhoff's law for thermal radiation.

OR

10. Write a short note on three-level laser system.

(SECTION : C—DESCRIPTIVE)

(*Marks* : 50)

Answer the following questions :

UNIT—I

1. *(a)* Deduce Faraday's law of electromagnetic induction in integral form. 3

(b) Establish Faraday's law of electromagnetism, $e \frac{d}{dt}$, when a conducting loop moves with a velocity $\vec{v}$ in a uniform magnetic field. 5

(c) Distinguish between conduction and displacement current. 2

OR

2. *(a)* Derive the four Maxwell's equations. Give the physical significance of the equations. 6

(b) Consider a parallel-plate capacitor which is maintained at potential of 200 V. If the separation distance between the plates of the capacitor is 1 cm and area of the plates is 20 sq. cm, calculate the displacement current for the time in s. 4

UNIT—II

3. *(a)* Deduce the general equations for electromagnetic wave satisfied by $\vec{E}$ and $\vec{B}$ in free space. Write the solutions for it. 6

(b) If a 500 watt laser beam is concentrated by a lens into a cross-sectional area of $10^{10}\ m^2$, find the value of Poynting vector and the amplitude of electric field. 4

OR

4. *(a)* Derive the expression for the energy per unit volume of the electromagnetic wave and using this expression, deduce the expression for the equation of continuity. 7

(b) Explain in brief the momentum and pressure of electromagnetic wave. 3

UNIT—III

5. *(a)* State Maxwell's equation for electromagnetic waves in a conducting medium. Hence derive the wave equation. 2+4=6

(b) Prove that the velocity of electromagnetic wave in a magnetic medium of magnetic permeability , electric susceptibility and conductivity 0, is given by c $\frac{1}{\sqrt{}}$. 4

OR

6. *(a)* What is plane polarized electromagnetic wave? Derive the wave equations for a plane polarized electromagnetic waves having finite values of permeability and susceptibility for a charge-free conducting medium. 2+5=7

(b) What do you mean by Brewster's angle? 3

UNIT—IV

7. *(a)* Deduce Coulomb gauge for electromagnetic wave and explain why it is called transverse gauge. 4+2=6

(b) Obtain Lorentz's force law from electromagnetic potential. 4

OR

8. *(a)* Deduce Poisson's equation using vector potential in terms of current density and also deduce Laplace equation using scalar potential in terms of charge density. 3+3=6

(b) The magnetic scalar potential due to a magnetic dipole at a point on its axis situated at a distance of 20 cm from its centre is found to be $1\ 2\ \ 10^{\ 5}$ Tm. Find the magnetic moment of the dipole. 4

UNIT—V

9. Starting from quantum hypothesis, establish Planck's radiation law. Deduce Wien's law and Rayleigh-Jeans law from Planck's radiation law. 7+3=10

OR

10. *(a)* Write the construction, working principle and uses of He-Ne laser. 7

(b) What do you know about population inversion? 3

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