

Ref. No.: EX/SC/PHY/UG/CORE/TH/13/2023
B.S.C. PHYSICS THIRD YEAR SECOND SEMESTER
SUPPLEMENTARY EXAMINATION
Subject: ELECTROMAGNETIC THEORY

Time: 2 Hours

Full Marks: 40

Answer any four questions. Symbols used have their usual meanings.

1. (a) A parallel plate capacitor made of two circular disks of radius R separated by small distance d , are connected to an external source of alternating emf with voltage $V(t) = V_0 \sin \omega t$. Find out the ratio of capacitor charging current (i_c) and displacement current (i_d) in the circuit.
(b) Discuss about the importance of Maxwell's modification to Ampere's law.
(c) The differential form of Poynting's theorem can be written as $\frac{\partial u}{\partial t} = -\vec{\nabla} \cdot \vec{S}$ where u is the total energy density (mechanical + electromagnetic) of the electromagnetic field and \vec{S} is the Poynting vector. How this mathematical statement imply the conservation of energy? Explain. Write down the unit of Poynting vector. 3 + 3 + (3 + 1)
2. (a) Is electromagnetic wave propagating through unbounded medium always transverse in nature? Explain.
(b) Find out the expression for energy density and intensity of an electromagnetic wave propagating in conducting medium.
(c) Show that the skin depth in a poor conductor is independent of the frequency of incident electromagnetic wave. 4 + 4 + 2
3. (a) An EM wave falls obliquely on the interface of two media and the electric field vector lies in the plane of incidence. Assume the magnetic field vector along the y -axis. Draw a clear diagram showing incident, reflected and transmitted rays along with their respective field vectors. Show that,
 $E_r \cos \theta_r - E_i \cos \theta_i = -E_t \cos \theta_t$.
(b) Polystyrene has a relative permittivity of 2.7. If an EM wave is incident on polystyrene from air at an angle $\theta_i = 30^\circ$, calculate the angle of transmission θ_t . Repeat the calculation if the media are interchanged. (2 + 3) + (3 + 2)
4. (a) Using the expressions of \vec{E} and \vec{B} for p-polarised wave, prove that the angle of incidence the angle of reflection are equal.
(b) The x and y components of the electric field are given by $E_x = E_0 \sin(kz - \omega t + \pi/3)$ and $E_y = E_0 \sin(kz - \omega t - \pi/6)$. Determine the state of polarization and show it in a suitable diagram.
(c) Two mutually perpendicular EM waves are allowed to superpose on each other. Establish the conditions when the resultant wave is linearly polarized. 4 + 3 + 3
5. (a) Explain the terms: (i) Dielectric tensor, (ii) Double refraction, (iii) Optic axis. Give schematic diagrams where needed.
(b) What is a quarter wave plate? Find out the expression of minimum thickness for a quarter wave plate in terms of the incident wavelength and refractive indices of e-ray and o-ray. (2 + 2 + 2) + 4
6. (a) Write down the boundary conditions for electric and magnetic fields considering the electromagnetic wave propagation through a long hollow metallic wave guide with rectangular cross-section. Prove that TEM mode of electromagnetic wave cannot exist in the hollow wave guide.
(b) For a given rectangular waveguide of dimension 2.28 cm \times 1.01 cm, Find out the TE and TM modes that will propagate if the driving frequency is 1.70×10^{10} Hz? (2 + 4) + 4