

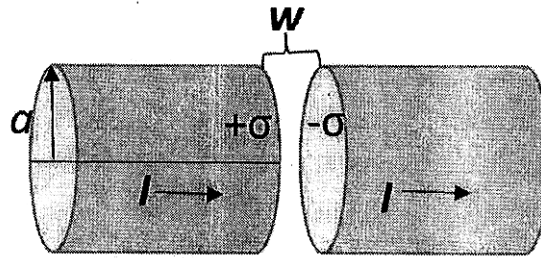
Ref. No.: Ex/SC/PHY/UG/CORE/TH/13/2022(S)
 B.SC. PHYSICS THIRD YEAR SECOND SEMESTER
 SUPPLEMENTARY EXAM - 2022
 Subject: ELECTROMAGNETIC THEORY

Time: 2 Hours

Full Marks: 40

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

1. (a) A cylindrical thick wire of radius a carries a steady current I which is uniformly distributed over its cross-section. A narrow gap of width $w \ll a$ is created in the wire to form a parallel plate capacitor as shown in figure below.



- (i) Find out the displacement current density.
 (ii) Find the magnetic field inside the gap.
- (b) Discuss about the importance of Maxwell's modification to Ampere's law.
 (c) Write down the Poynting's theorem. (2 + 3) + 3 + 2
2. (a) Find out the expression for energy density and intensity of an electromagnetic wave propagating in 'free space'. Will they remain same if the space is filled by a dielectric medium of dielectric constant ϵ ? Explain.
 (b) Show that the skin depth in a poor conductor is independent of the frequency of electromagnetic wave. (4 + 2) + 4
3. (a) What are p -polarisation and s -polarisation? By suitable diagram, explain the difference between them.
 (b) A p -polarised wave is incident on the interface of two non-magnetic dielectrics of refractive indices n_1 and n_2 . If the electric field of the incident beam is given by $\vec{E}_i = \vec{E}_0 \exp[i(\vec{k}_1 \cdot \vec{r} - \omega t)]$, then write down the expressions of electric field and magnetic field vectors of incident, reflected and transmitted beams.
 (c) Using the expressions of \vec{E} and \vec{B} for p -polarised wave, prove that the angle of reflection is equal to the angle of incidence. (2 + 1) + 3 + 4
4. (a) For an s -polarised wave falling on the interface of two non-magnetic dielectrics, establish the expressions of reflectance and transmittance.
 (b) The x and y components of an electric field are given by the following equations:

$$E_x = \frac{\sqrt{3}}{2} \cos(\omega t - kz); \quad E_y = \frac{1}{2} \cos\left(\omega t - kz + \frac{\pi}{4}\right)$$
 Draw a schematic diagram of the state of polarization with proper explanation.
 (c) Using the concept of dielectric tensor, explain uniaxial and biaxial crystals. 5 + 3 + 2

5. (a) "When the incident light is purely p -polarized, there will be no light to reflect if the reflected and refracted rays are orthogonal" – Explain.
(b) What is a quarter wave plate? What will be the thickness of a quarter wave plate corresponding to an incident beam of $\lambda = 5893 \text{ \AA}$? Given, for that crystal, $n_o = 1.65836$ and $n_e = 1.48641$.
(c) Write down the differences between ordinary and extra-ordinary rays.
(d) An unpolarised beam enters an anisotropic crystal like calcite. What are the states of polarisation of the two emergent beams? Show them in a schematic diagram. 3 + (1 + 2) + 2 + 2
6. (a) Prove that TEM mode of electromagnetic wave cannot exist in a hollow wave guide.
(b) What is the lowest possible TE mode that can propagate in a rectangular waveguide?
(c) What is the basic structure of an optical fiber?

5 + 3 + 2