RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIFTH SEMESTER EXAMINATION, DECEMBER 2018

THIRD YEAR [BATCH 2016-19]

Date : 22/12/2018 **PHYSICS (Honours)**

Time : 11.00 am – 1.00 pm **Paper : VI** Full Marks : 50

Answer **any five** from the following: [5 × 10]

1. a) Write down the differential forms of Maxwell's field equation in vacuum in presence of sources. (2)

   b) Using Maxwell's equations establish the continuity equation of charge $\vec{\nabla}\cdot\vec{J} = -\frac{\partial \rho}{\partial t}$. (2)

   c) Sea water has resistivity 0.4 Ωm and its dielectric constant 81. Find the ratio of the amplitudes of the conduction and displacement current densities when the applied field E is oscillating at 100 MHz. (3)

   d) In absense of sources show that the Maxwell's equations are invariant under the transformation (3)

   $$\vec{E}' = \vec{E}\cos\theta + c\vec{B}\sin\theta$$

   $$\vec{B}' = -\left(\frac{\vec{E}}{c}\right)\sin\theta + \vec{B}\cos\theta$$

   where c is the speed of light in vacuum and θ is a parameter. Interpret this invariance for $\theta = \pi/2$.

2. a) If the medium is source free obtain the wave equations for the $\vec{E}$ and $\vec{B}$ fields. If $\vec{E} = \vec{E}_0 e^{j(\vec{k}\cdot\vec{r}-\omega t)}$ and $\vec{B} = \vec{B}_0 e^{j(\vec{k}\cdot\vec{r}-\omega t)}$ are the solutions of the respective wave equations, show that both of them represent transverse wave propagating along the direction of $\vec{k}$. Hence show that $E = vB$, where v is the speed of the wave. (2+2+1)

   b) What is wave impedance? Write down the expression of it in a non conducting media. (2)

   c) Show that the time averaged Poynting vector is given by: (3)

   $$\langle\vec{\varsigma}\rangle = \frac{1}{2}\mathrm{Re}\left(\vec{E}\times\vec{H}^*\right)$$

   and evaluate it for the wave equation for the waves given in part (*a*).

3. a) Deduce the wave equations for the electromagnets fields $\vec{E}$ and $\vec{H}$ in a medium with finite conductivity σ. Assuming a plane harmonic wave propagating along +z direction show that the propagation constant k is necessarily complex. Hence show that the fields are exponentially attenuated along z axis. (2+2+1)

   b) If $k = \alpha + i\beta$ find out the expression for α and β in terms of $\in, \mu, \sigma$ of the medium and frequency of the propagating wave. (3)

   c) Two em waves with frequency ω_1 and ω_2 (when $\omega_1 > \omega_2$) are trying to penetrate a medium with high σ. Mention with reason which one penetrate much? (2)

4. a) A 2 KHz electromagnetic wave propagates in a non magnetic medium having a relative permittivity 20 and a conductivity 3.85 S/m. Determine if the material is a good conductor or otherwise. Calculate the phase velocity of the wave, the propagation and attenuation constants, the skin depth and the intrinsic impedance. (5)

b) Show that in a very good conductor the electromagnetic field energy is mostly magnetic. (3)

c) What do you mean by loss tangent? (2)

5. a) Use Maxwell's equations to obtain the boundary conditions to be satisfied by the electric and magnetic fields at an infinite planer interface of two linear isotropic dielectrics. (5)

b) Deduce Fresnel's equations for *s* polarised em waves incident obliquely at a planer interface of two uniform dielectric. It is assured $\in_1 \neq \in_2$ but $\mu_1 = \mu_2$. (5)

6. a) Explain what you mean by a dispersive medium. Use a suitable model of a dispersive dilute dielectric to find the dispersion relation of an EM wave travelling in the medium. Hence obtain an expression for the refractive index, *n*, in the limit of zero damping. Discuss the behaviour of $n(\omega)$ as a function of ω. (5)

b) Find the width of the anomalous dispersion region for the case of single resonance at frequency ω_0. Assume $\gamma \ll \omega_0$. Show that the index of refraction assumes its maximum as minimum values at points where the absorption coefficient is at half-maximum. (5)

7. a) Give Huygen's construction for the ordinary and extra-ordinary rays in a quartz crystal, cut such that the optic axis is parallel to the refracting surface. (3)

b) If $\vec{E} = \hat{i}E_{0x}\cos(kz - \omega t) - \hat{j}E_{0y}\sin(kz - \omega t)$ represents a polarised wave, find out the state of polarisation. (2)

c) What do you understand by rotatory dispersion? (2)

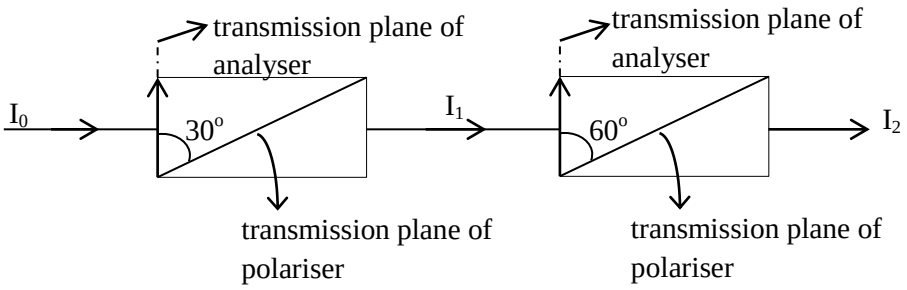
d) Describe the construction and principle of a half-shade polarisation. (3)

8. a) Describe the construction of a quarter wave plate. (3)

If a quarter-wave plate and a half wave plate were both given to you, how would you proceed to distinguish them from each other. (2)

b) Calculate the thickness of a quarter half wave plate for the Fraunhofer *C* line (wave length for the *C* line is 6563 A.U) for which the extraordinary and ordinary refractive indices of quartz are 1.55085 and 1.54181 respectively. (3)

c)



where I_0 is the intensity of incident polarised light. Find out the intensity of I_2 in respect of I_0. (2)

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