RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIFTH SEMESTER EXAMINATION, DECEMBER 2015

THIRD YEAR [BATCH 2013-16]

Date : 22/12/2015 **PHYSICS [Hons]**

Time : 11 am – 1 pm **Paper :** VI Full Marks : 50

Answer **any five** questions :

1. a) Find expressions for electrical energy density U_e in terms of charge density ρ and electric field $\vec{E}$. [5]

   b) A medium like copper conductor which is characterised by the parameters $\sigma = 5\cdot 8\times 10^7$ mho/m, $\in_r = 1$, $\mu_r = 1$ supports a uniform plane wave of frequency of 60Hz. Find the attenuation constant, propagation constant, intrinsic impedance, wave length and phase velocity of the wave. [5]

2. a) Write down the Ampere's circuital law in differential form in free space and in magnetic material medium. Show that the displacement current is consistent with conservation of charge. A parallel plate capacitor C charged with Q is discharging through a resistor R, find an expression of displacement current for this case. [7]

   b) Show mathematically how Maxwell's fourth equation related to Ampere's circuital law was modified by Maxwell himself for time varying field. [3]

3. a) Using the Maxwell's equations show that the electric vector in free space satisfies a wave equation. Prove that the wave is transverse in nature. [5]

   b) A linearly polarized plane wave with amplitude E_0 = 10 V/m propagating along a line in X-Y plane at an angle 45^0 to X-axis with X-Y plane as its plane of vibration. Find an expression for the electric field and the flux density in vacuum. [5]

4. a) Define skin depth in a conducting medium and find its value for an EM Wave in copper at frequency f = 60Hz and f = 100 MHz. For Copper, $\sigma = 5\cdot 8\times 10^7$ mho/m, $\mu_r = 1$, $\in_r = 1$. [2+2]

   b) A good metal surface acts as good reflector of electromagnetic wave for frequency smaller than plasma frequency— Explain this result. The charge density of ionosphere is $10^{12}/m^3$, estimate frequency above which satellite communication is feasible. [6]

5. a) Write the equation of motion of electron in radiation field. [1]

   b) A monochromatic plane electro magnetic wave of angular frequency ω is incident in a gaseous medium containing N number of molecule per unit volume and each molecule has f_j electrons with characteristic frequency ω_j and damping factor γ_j. Show that the dielectric constant of the medium is given by $K = \frac{\varepsilon}{\varepsilon_0} = 1 + \frac{Ne^2}{m\varepsilon_0}\sum_{j=1}^{n}\frac{f_j}{(\omega_j^2 - \omega^2) - i\gamma_j\omega}$

   From the above expression derive expressions for the refractive index of the medium. Show graphically the variation of the two quantities with the frequency of the incident wave. [5+1+3]

6. Consider the incidence of electromagnetic wave at the boundary with electric field parallel to the plane of incidence, between two non-conducting media. Write the electric and magnetic field vectors for the incident, transmitted and reflected wave. Give the boundary conditions, hence find the expression for reflection and transmission coefficient's. [2+2+6]

7. a) Explain the terms (i) Optical axis of a crystal (ii) Uniaxial crystal [2]

   b) How one can combine two linear vibrations to get circular vibrations, find an expression of it. [4]

   c) It is desired to rotate the direction of polarization of a linearly polarized light by 90° using two polaroid filters. Explain how this can be done and find the final intensity in terms of incident intensity. [4]

8. a) What is Rayleigh's Scattering? If the incident EM wave has electric vector in the x axis and propagation vector in the z axis, the instantaneous amplitude can be expressed as

$$x = \frac{e}{m}\frac{E_0 e^{-i(\omega t - kz)}}{(\omega_0^2 - \omega^2) - i\gamma\omega},$$

symbols have their usual meaning. Find the scattering cross section in terms of wavelength of incident EM radiation on atoms. Why the setting sun is red and sky is blue? [2+6+2]

9. a) Establish Poynthing's theorem regarding rate of Power flow at certain point. [6]

b) An elliptically polarized wave has an electric field.

$$\vec{E} = \sin(\omega t - \beta z)\hat{a}_x + 2\sin(\omega t - \beta z + 75°)\hat{a}_y \ V/m$$

Find the Power density conveyed by the wave in free space. [4]

———— × ————