RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIFTH SEMESTER EXAMINATION, DECEMBER 2016

THIRD YEAR [BATCH 2014-17]

Date : 22/12/2016 **PHYSICS [Honours]**

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

Answer <u>any five</u> questions [5×10]

1. a) Starting form Maxwell's equation in vacuum derive the electromagnetic wave equation. [2]
   b) The intensity of sunlight hitting the earth is about 1300 w/m^2. Assuming normal incident, (i) obtain the magnitude of electric and magnetic fields when strikes a perfect reflector. (ii) If sunlight strikes a perfect absorber, what pressure does it exert? [4]
   c) A parallel plate air gap capacitor is made up of two plates of area 10 sq. cm. each keeps at a distance of 0.1mm. A sine wave of amplitude 1 V and frequency 1 MHz is applied across the capacitor, find the displacement current through the capacitor. [4]

2. a) Show that the electric and magnetic vectors are mutually perpendicular in an electromagnetic wave. [3]
   b) Show that the electromagnetic wave energy is equally shared between electric and magnetic field in a isotropic dielectric medium. [3]
   c) The dispersion relation for electromagnetic wave of angular frequency ω propagating in a media is $\frac{\omega^2}{c^2} = k^2 + A_0^2$, where, $k = \frac{2\pi}{\lambda}$, is the wave number and λ is the wavelength, A_0 is a constant and c is the speed of the wave in free space. Find the product of phase and group velocity. [4]

3. a) Two electromagnetic plane wave propagating in vacuum media with their electric field vectors $\bar{E}_a = E_0 \cos(kz - \omega t)\hat{i}$ and $\bar{E}_b = E_0 \cos(kz + \omega t)\hat{i}$. Find the magnetic field vector corresponding to the superposition of these two waves. [5]
   b) A good conductor can not be identified by the value of the conductivity σ of the conductor alone in case of propagation of electromagnetic wave. Explain. [2]
   c) Show that in a conductor the electric and magnetic field of propagating electromagnetic wave are no longer in phase. [3]

4. An un-polarized light is incident on an air dielectric interface. The electric field of the reflected light is given by, $\bar{E} = E_0 \hat{i} e^{\frac{ik}{2}(\sqrt{3}y+z)-i\omega t}$, where k is the propagation constant in air and ω is the angular frequency of the light. Assuming magnetic permeability $\mu = \mu_0$.
   a) Determine the dielectric constant of the second medium.
   b) Determine the direction of the Poynting vector in the dielectric medium. [6+4]

5. Derive Fresnel's equations for reflection and refraction of electromagnetic wave at a plane boundary separated by two media when the incident wave only have E vector parallel to the plane of incidence. Also show that there is an angle of incidence for which there is no reflected wave. [7+3]

6. Derive the expression for the differential scattering cross-section for Thomson scattering of radiation by electrons. Why sky appears blue and setting Sun red? [8+2]

7. a) Let a beam of parallel rays (equivalent to a plane wave front) is allowed to fall with an oblique incidence on the surface of an uniaxial crystal. The optic axis makes an angle θ with the interface. Draw the wave fronts of E wave and O wave. Also show the ray directions. [5]

   b) Show that the normal dispersion relation follows from damped oscillating dipole. [3]

   c) What do you mean by anomolus dispersion? [2]

8. a) What should be the thickness of a quarter wave plate? Is it strictly $\frac{\lambda}{4}$? Explain with reason. [4]

   b) Find the minimum thickness of a quarter-wave plate of quartz for light of wavelength 589·3 nm. The refractive index of quartz for E-ray and O-ray are 1·5533 and 1·5442 respectively. [3]

   c) Rotation in optically active solution is expressed as $\theta = slm$, where s is the specific rotation, m is the amount of solute in mg dissolved in 1 cc solution and l is the length of solution in decimetre. Sugar solution is dextrarotatory. If we reflect back the light with the help of a mirror after traversing a path length l, what will be the net rotation of plane of polarisation at the starting point? [3]

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