PHY 103N: PHYSICS 2, (2007-2008, Semester -II) *(SAR/HW)*

Department of Physics, I.I.T. Kanpur

Assignment - 8 **Electromagnetic Waves**

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1. Write the E and B fields of a plane wave of frequency ω traveling in vacuum

   a) linearly polarized along the x direction and traveling in the increasing y direction.

   b) Right circularly polarized light traveling in the increasing x direction.

   c) linearly polarized along the x direction and traveling from the origin to the (0,1,1) direction.

2. Obtain the $\vec{B}$ field associated with the given EM wave, carefully identify the polarization state, amplitude, wavelength, angular frequency, direction of propagation. (in S.I Units)
   $\vec{E} = 10\sin(\omega t + 6 \times 10^5 z)\hat{i}$ Find the Poynting vector. How much energy is contained in a cube of length 1 mm? The surfaces of the cube are given by x = 0, $1mm$, y = 0, $1mm$, z = 0, $1mm$. Identify the cube surfaces through which the energy enters and leaves the cube.

3. Calculate the magnitude of the E and B fields associated with a 2 mW (Power) Helium-Neon laser beam (used by you in the lab, $\lambda = 632.8nm$) propagating in (i) vacuum and (ii) glass of refractive index 1.5. The beam area is 0.5 mm^2. Dwell on the relative strengths of the E and B fields and thus the way light propagates in a medium.

4. Calculate the radiation pressure exerted by the above laser beam (problem 3) on a perfectly absorbing medium and also a perfectly reflecting medium.

5. Prove that the locus of the tip of the electric field vector forms an ellipse in a plane perpendicular to the direction of propagation. **Hint:** Eliminate the $(kz - \omega t)$ dependence to obtain equations relating the $x - y$ components.

6. A light wave is incident on crown glass ($n = 1.52$) at angle $\theta = \pi/6$. Determine the amplitude reflection and transmission coefficients when the beam is linearly polarized in (i) the plane of incidence and (ii) normal to the plane of incidence. Determine also the angle at which the reflected wave would be completely polarized.

7. Plot and discuss the Fresnel reflection coefficients for the σ (perpendicular to the plane of incidence) polarized light. Contrast these results with the π polarized light discussed in the class.

8. A 3 GHz EM wave propagates in a conducting medium with dielectric constant 2.5 and conductivity 7.1×10^7 S/m. The relative permeability is close to 1.

   (a) Determine the distance over which the amplitude of the wave is reduced to half its value.

   (b) Determine the wavelength and the phase velocity

   (c) Assuming that $\vec{E} = 50\hat{j}\sin(-6\pi \times 10^9 t + \pi/3)$, write the expression of the magnetic field for general (x,t).