SB/HCV

PHY 103: General Physics 2 (2014 – 2015, Semester – I)

Department of Physics, Indian Institute of Technology - Kanpur

Assignment- 12

(ONLY the *ed questions will be DONE in the tutorial)

1. The magnetic vector of a plane electromagnetic wave is described as follows:

$$\mathbf{B} = \hat{k}B_0 \cos\left[\left(10 meter^{-1}\right) y + \left(3\times10^9 s^{-1}\right) t\right]$$

where $\hat{k}$ is a unit vector in the z-direction. (a) What is the wavelength λ of the wave? (b) What is the period T of the wave? (c) In which direction does this wave propagate? Indicate the direction of propagation with a unit vector and an appropriate sign (+ or –). (d) Write an expression for the electric vector **E** of the wave in terms of the quantities given and the speed of light c. (e) What is the time-dependent Poynting vector associated with this wave? Write the magnitude in terms the speed of light c, B_0 and μ_0, in addition to the numerical constants given. Do not use ε_0 in your final expression.

2 Write expressions for the E and B fields which constitute a plane monochromatic wave of wavelength λ_0 and electric field amplitude E_0, traveling in the positive z-direction. The wave is linearly polarized in the direction making an angle 45^0 to the x-axis.

3*. Write down the electric field for a monochromatic, plane wave of amplitude E_0, frequency ν, and phase angle zero, which is traveling in the direction from the origin to the point (1,1,1), with polarization parallel to the x-y plane.

4. Calculate the amplitude of electric field of light from a 5W LED bulb at a distance of 2m from it. Assume that all the power given to the bulb is emitted as light and isotropically in all directions.

5. A plane electromagnetic field moving in free space with electric field amplitude 0.4 V/m falls perpendicularly on a sheet and gets absorbed. Find the momentum transferred to the sheet in 15 seconds.

6. A parallel beam of light with wavelength 400 nm has an intensity of 25 mW. How many photons cross an area of 1mm^2 per second placed perpendicular to the beam?

7*. The electric field in a medium is written as $E = \left[\sin\left(\alpha x - \omega t\right) + \sin\left(\beta x + 2\omega t\right)\right]\hat{j}$. For what condition on a and β, can this be a valid expression for EM wave?

8. The radiation coming from a distant galaxy ~~shows~~ source. The hydrogen microwave line at 25·0 cm where the laboratory value for this wave length is 22·5 cm. What is the velocity of the galaxy which it emitted this radiation?

9*. The electric field in a region is given by $\mathbf{E} = 2E_0 \cos kz \cos \omega t \, \hat{i}$. (a) Show that it satisfies the wave equation $\nabla^2 \mathbf{E} = \frac{1}{v^2} \frac{\partial^2 E}{\partial t^2}$ with $v = \omega / k$. (b) Find the magnetic field corresponding to this E-field. (c) Find the Poynting vector $\mathbf{S}$ and discuss the direction of energy flow at a given time t. (d) Find $\langle S \rangle$, the average of $\mathbf{S}$ over a time period at a given place.