Study Material

Text Book

Elements of Electromagnetics, 6th Ed.
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Oxford University Press

Study Electromagnetic Waves

Read Chapter 10, pp. 454-488.

Wave Parameters

An electromagnetic wave has the following electric and magnetic field components.

$$\vec{E}(\vec{r},t) = \left(63.1347\hat{a}_x + 6.4873\hat{a}_y - 21.4691\hat{a}_z\right)\cos\left(2.8274\times10^{10}t - 28.6454x - 49.6153y - 99.2306z\right)$$

$$\vec{H}(\vec{r},t) = \left(-0.0401\hat{a}_x + 0.1614\hat{a}_y - 0.0691\hat{a}_z\right)\cos\left(2.8274\times10^{10}t - 28.6454x - 49.6153y - 99.2306z\right)$$

Problem #1

Write the polarization vector of this wave.

Problem #2

What kind of polarization does this wave have (i.e. LP, RCP, LCP, or EP)?

Problem #3

Calculate the frequency of the wave in units of Hertz.

Problem #4

Write the wave vector for this wave.

Problem #5

Calculate the refractive index of the material this wave is in.

Problem #6

Calculate the impedance of the material.

Problem #7

Calculate the dielectric constant of the material.

Problem #8

Calculate the relative permeability of the material.

Problem #9

Calculate the RMS Poynting vector of the wave.

Problem #10

Calculate the angle between the Poynting vector and the wave vector.

Scattering at An Interface

A right-hand circularly polarized wave at 1.5 GHz is propagating through a material with ε_r = 6.2 and μ_r = 2.0 and arrives at an interface with air. It is incident at an elevation angle of 15° and an azimuthal angle of 45°. The wave has an amplitude of 12 V/m. The interface lies in the *x-y* plane.

Problem #11

Calculate the angle of incidence θ_1?

Problem #12

Write the expression for the incident wave vector $\vec{k}_1$.

Problem #13

Write the unit vectors $\hat{a}_{\text{TE}}$ and $\hat{a}_{\text{TM}}$ in the direction of the TE and TM polarizations, respectively.

Problem #14

Write the polarization vector of the incident electric field $\vec{E}_{\text{inc}}$.

Problem #15

Calculate the critical angle and the Brewster's angles for this configuration for both polarizations.

Problem #16

Calculate the reflection and transmission coefficients for both polarizations.

Problem #17

Calculate the percent reflectance and transmittance for both polarizations. Verify conservation of energy.

Problem #18

Write expressions for the reflected and transmitted wave vectors $\vec{k}_{\text{ref}}$ and $\vec{k}_{\text{trn}}$. Do the vectors $\vec{k}_{\text{inc}}$, $\vec{k}_{\text{ref}}$, and $\vec{k}_{\text{trn}}$ have anything in common?

Problem #19

Write time-domain expressions for the incident, reflected, and transmitted electric fields $\vec{E}_{\text{inc}}(\vec{r},t)$, $\vec{E}_{\text{ref}}(\vec{r},t)$, and $\vec{E}_{\text{trn}}(\vec{r},t)$.