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.

\[
\vec{E}(\vec{r},t) = (63.1347\hat{x} + 6.4873\hat{y} - 21.4691\hat{z})\cos(2.8274 \times 10^4 t - 28.6454x - 49.6153y - 99.2306z)
\]

\[
\vec{H}(\vec{r},t) = (-0.0401\hat{x} + 0.1614\hat{y} - 0.0691\hat{z})\cos(2.8274 \times 10^4 t - 28.6454x - 49.6153y - 99.2306z)
\]

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 $\varepsilon_r = 6.2$ and $\mu_r = 2.0$ 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 $\theta$?

Problem #12
Write the expression for the incident wave vector $\mathbf{k}_1$.

Problem #13
Write the unit vectors $\hat{a}_{TE}$ and $\hat{a}_{TM}$ in the direction of the TE and TM polarizations, respectively.

Problem #14
Write the polarization vector of the incident electric field $\mathbf{E}_{inc}$.

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 $\mathbf{k}_{ref}$ and $\mathbf{k}_{tn}$ . Do the vectors $\mathbf{k}_{inc}$, $\mathbf{k}_{ref}$, and $\mathbf{k}_{tn}$ have anything in common?

Problem #19
Write time-domain expressions for the incident, reflected, and transmitted electric fields $\mathbf{E}_{inc}(\mathbf{r}, t)$, $\mathbf{E}_{ref}(\mathbf{r}, t)$, and $\mathbf{E}_{tn}(\mathbf{r}, t)$. 