PreLab 10 – Plane wave reflection and refraction

In this lab we will be exploring the reflection, transmission and polarization of plane waves at optical frequencies.

PL10.1. Snell’s law is nothing more than a consequence of our EM boundary conditions, in particular the continuity of tangential electric field. The figure below shows the crests of a plane wave incident from air and refracting into gelatin (or anything else). Remembering the fact that the optical wavelength will be smaller by a factor of \( n_{gelatin} \) in the gelatin, derive Snell’s law by setting the distance between peaks on the boundary equal in both regions.

\[
\theta_{trans} = \theta_{inc} / n_{gelatin}
\]

PL10.2. Calculate the fraction of the incident power reflected when the incident beam is at normal incidence and the relative permittivity of the gelatin is given by \( \varepsilon_r \).
PL10.3 Consider the figure below in which the direction of propagation has been reversed. As you increase the incidence angle in the gelatin, the transmitted angle will increase until it reaches 90 degrees, at which point the wavelength along the boundary will be equal to $\lambda$. Further increases in the incidence angle result in a wave which can not propagate in air, causing the entire optical power to reflect back into the gelatin. Solve for the incidence angle at which this “total internal reflection” just occurs. Could this happen in the figure for the first problem, above?

![Image of a beam of light incident on a gelatin-air boundary](image1)

PL10.4. The power from an unpolarized light source (e.g. a light bulb) is measured with a power meter to be $P_{\text{total}}$. We then insert different perfect polarizers and measure the power. What is the measured power when the following polarizers (and just these) are inserted in the order shown?

1. V
2. H
3. V and H
4. V and 45
5. V and 45 and H

![Image of polarizers illustrating PL10.4](image2)