Linear Polarizer

Typical sources of light (lightbulb, sun, candle) produce unpolarized light. The \( \vec{E} \) field vector varies randomly in direction transverse to the direction of propagation:

Plan wave traveling out of the page:

\[ \text{(traveling out)} \]

A linear polarizer blocks all electric field components perpendicular to its transmission direction: transmission axis

polarizer film
What happens:

Diagram:

- Unpolarized light
- Vertical polarizer
- Vertically polarized light
- Horizontal polarizer

No transmitted light!

How much light is passed?  

Assume 100% linearly polarized light is input, and that the polarizer axis has an angle of $\theta$ compared to the polarization angle of the input light.
\[ |\vec{E}_{\text{transmitted}}| = |\vec{E}_0| \cos \theta \] (because of vector projection)

\[ \text{Intensity transmitted} \propto |\vec{E}_{\text{transmitted}}|^2 \]

\[ I_{\text{trans}} = |\vec{E}_0|^2 \cos^2 \theta \]

\[ I_{\text{trans}} = I_0 \cos^2 \theta \]  
Mollier Law.

**Question:** In the lab the polarization axis of the polarizer is unmarked. How can we determine the direction of a polarizer if the axis is unmarked?

**Answer:** You need a source of light which is at least partially polarized, and whose polarization axis is already known to you.
Polarization of Reflected Light: Brewster's Angle.

In general, whenever light is reflected from a surface, its polarization is altered in some way.

To study this, we must define the two polarizations directions with respect to the surface:

"P-wave"  
air

"In the plane of incidenes"  

"S-wave"  
glass  
air

reflected

"Parallel to the glass surface"
Reflectance as a function of angle of incidence.

Described by the Fresnel Equations. For a smooth dielectric surface like glass, it looks like this:

\[ \theta = \text{"Brewster's Angle"} \]

\[ \Rightarrow \text{At Brewster's Angle, no } p\text{-wave light will reflect.} \]

\[ \Rightarrow \text{When angle of incidence } = \theta, \text{ } p\text{-wave reflectance is zero.} \]
Question: What determines the value of Brewster's angle?

Answer: The ratio of the indices of refraction:

\[ \tan \theta_B = \frac{n_2}{n_1} \]

Consequence: By measuring Brewster's angle in the lab, we can measure the index of refraction.

Clare: Glare is a reflection that happens at large angles of incidence.

[Diagram of a sailor on a boat with sunlight and water reflection]
Recall how reflection affects the polarization.

- How can you use this fact to determine the polarization axis of a specialty polarizer?
- Is reflected light enriched in s-wave light, or depleted in p-wave light?