# Polarization of light

## Abstract

*In this laboratory work, students will have to do measurements of polarized light and verify different physics laws experimentally. In particular, Malus' Law and Brewster's Law will be studied. Measurements of reflectivity and transmittance of a glass plate have to be compared with results predicted by the Fresnel Equations. The use of a pile of glass plates as a polarizer will also be studied. A polarimeter will be realized to measure the concentration of glucose in a solution (saccharimetry).*

### 1. Demonstration of the Malus' Law

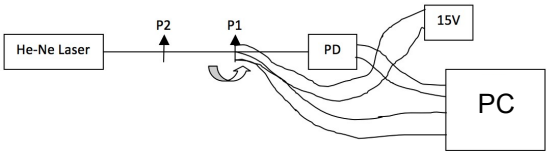


*Figure 1.*

A polarizer is a device that converts unpolarized or mixed-polarized light into (usually linearly) polarized light. If a polarizer is applied to an already polarized light, it is called an analyzer.
When linearly polarized light is analyzed, the amplitude of the entering light is projected onto the axis of the polarizer. If Ψ is the angle between the light's initial polarization and the axis of the polarizer, the emerging light has a linear polarization, which is parallel to the axis of the polarizer and has an amplitude of $A_{out}=|A_{in}\cdot\cos\Psi|$.
The intensity received by a detector is therefore given by:

$$I(\Psi)= A_{out}^{2}(\Psi) =I_{in}\cdot\cos^{2}\Psi$$

This law for the analysis of a linearly polarized light is called Malus' Law.

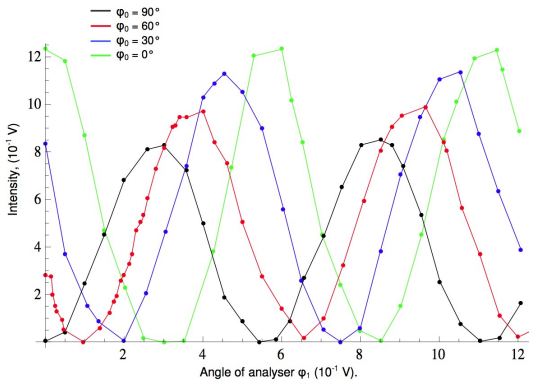


*Figure 2.*

The student will observe the Malus' law using a second polarizer (P2), set at different angle (φ)

### 2. Transmission and reflection through and on a glass plate

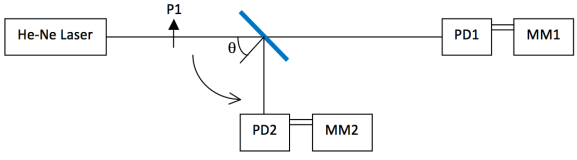


*Figure 3.*

The Fresnel equations describe the behavior of linearly polarized light at a phase boundary, which constitutes a change of refractive index between media.
The so-called plane of incidence is given by the incoming light wave and the plane perpendicular to the surface of the medium. One has to differentiate between polarization parallel and polarization orthogonal to the plane of incidence. The component of the electric field parallel to the plane is termed p-like and the component perpendicular to this plane is termed s-like.
The student measures the intensity of the reflected (R) and transmitted (T) beam from a glass plate for both s and p polarization getting similar curves as in Figure 4. With this experiment the student can also test Brewster's law.
Brewster's angle is an angle of incidence at which light with a particular polarization is perfectly transmitted through a surface, with no reflection.
It is defined as $\theta_B=\arctan(n_2/n_1)$

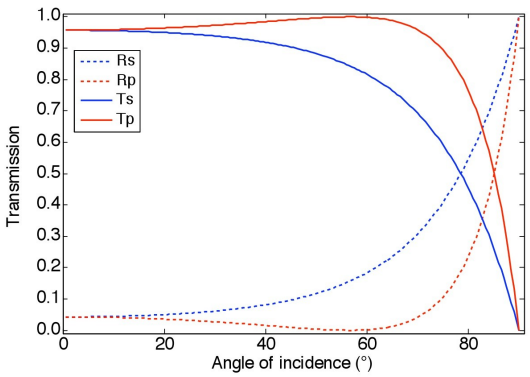


*Figure 4.*

The student should also study the s and p transmission for 2,3 and 4 glass plates.

### 3. Measurement of sugar concentration

A use of polarized light is to measure the sugar content of various syrups in the candy making industry. Sugars are optically active materials, causing a rotation of the plane of polarization of the light passing through the thickness of the sample. Thus, by constructing a device with a standard sample length and knowing the rotation constant of the sugar, the concentration of an unknown sugared liquid can be determined.

From the measurement of the change in the polarization angle of the light beam passing trough the glucose solution, the student measures the concentration of glucose.

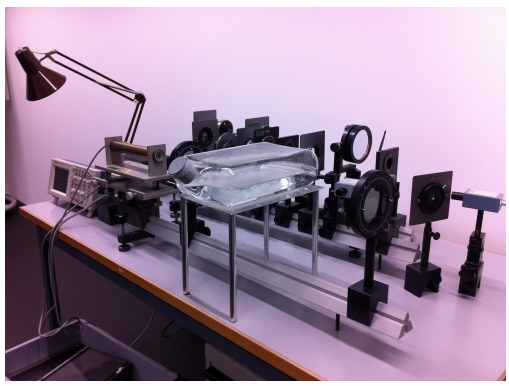

*Figure 5.*