**EXPERIMENT: POLARIZATION OF LIGHT**

[Equipment list: Laptop Computer, Computer Interface, Rotary Motion Tool, Light Sensor, Polaroid Material, Optics Track, LED Light, Plate Glass mounted to Screen, Protractor]

**Overview:**

As light waves propagate along a particular direction the vibrating Electromagnetic Field is directed perpendicularly to this direction of travel. Light coming from a light source is made up of various, independent wave trains of light that have their vibrating electric fields oriented randomly to each other, thus, the light is considered un-polarized.

Polarizing material, such as that in most sunglasses, is made up long chains of molecules imbedded into a plastic sheet. The orientation of these molecules (the axis of orientation) allow the light exhibiting electric fields in the same direction as these molecular chains (including components of the electric field in this direction) to pass through the polarizing material. The light waves that pass through the polarizing material are all plane-polarized. All other light waves with their electric fields oriented perpendicularly to the axis of orientation are absorbed by the polarizing material.

Propagation

Direction

figure 1

**Part 1: Polarizing Material**

The polarizing material is mounted in a frame that has the angle of the axis of the material marked upon it. By dialing the angle marked “0” to align with a small plastic tab the axis of the polarizing material will have a vertical orientation. Direct a light source so that you are looking at this light source through the polarizing material.

**Answer all questions in the Results section of your report. Letter your answers to reflect the letters of the questions.**

**Question A:** What happens to the intensity of the light source when looking at it through the polarizing material? Down slightly

**Question B:** What is the reason for this change in the light intensity? It blocks some of the light.

Rotate the polarizing material while looking at the light source.

**Question C:** Does there seem to be a change in intensity of the light coming through the polarizing material as you rotate it? Yes.

A circularly shaped piece of polarizing material should also be available on your table. Place this second polarizing material over the mounted polarizing material. Rotate the first polarizing material to an angle of 90°. Now, rotate the second polarizing material so that the minimum amount of light passes through both of them. Rotate the first polarizing material with the marked angles through a full 360° observing the intensity of the light passing through this combination.

**Question D:** For what angles does the light intensity reach a minimum? 90/300

**Question E:** Why does little to no light get through these two polarizing materials for these angles? Because the filters are set perpendicular to each other.

**Question F:** For what angles does the maximum intensity of light occur? 0/300

**Question G:** How does the intensity of this light viewed for question F compare to looking at the light source through just one polarizing material? It remains the same.

**Part 2: Malus’ Law**

The amount of light, its intensity, changes as one polarizing material is rotated with respect to another polarizing material. The light that passes through the first polarizing material (called the polarizer) becomes plane polarized. This polarized light is then allowed to pass through a second sheet of polarizing material (called the analyzer).

rotary motion tool

light sensor

light source

polarizer

analyzer

figure 2

The analyzer is mounted to a rotary motion tool connected to a computer interface. A light probe is mounted behind the analyzer and is also connected to the computer interface. Measure the intensity of this light passing through the analyzer as a function of the angle which the analyzer is rotated. Record these intensities as a function of angle in Table 1 on the Excel worksheet.

What is the maximum intensity, Imax, that was achieved? Record this on the Excel worksheet.

What is the minimum intensity, Imin, that was achieved? Record this on the Excel worksheet.

**Plot the Intensity vs. the Angle on graph paper. On the same graph paper plot the equation for Malus’ Law.**

Use the maximum intensity that you measured for Imax in the equation.

**Question H:** Does the data seem to follow Malus’ Law equation?

**Question I:** Malus’ Law utilizes a cosine squared function. Why not use a cosine function, or a sine function to represent the intensity of the light?

**Part 3: Polarization Due to Reflection**

When incident light strikes a surface at some angle other than normal to the surface the reflected light becomes polarized. As the light strikes the reflective surface those oscillations which are parallel to the surface will be reflected while those that are perpendicular will either be transmitted (if the material is transparent) or absorbed.

Set up a plate glass such that it can be rotated on the optical bench. Allow light to reflect off of the plate glass and through the mounted polarizing material. Use the analyzer attached to the rotary motion tool and the light sensor to determine if the reflected light is polarized.

glass plate

analyzer

light sensor

light source

figure 3

**Question J:** How did you determine if the reflected light from the glass plate is polarized? If it’s a sine-ish function.

**Part 4: Brewster’s Angle**

In part 3 you discovered that reflected light is polarized to some degree. There is a particular angle of the incident light that causes the reflected light to be maximally polarized. Use the setup in part 3 and vary the angle at which the light strikes the plate glass. You will have to rotate the plate glass to achieve what is called Brewster’s Angle. This angle is dependent upon the index of refraction of the transparent material of which the light is reflected. Measure Brewster’s Angle from the normal to the face of the glass plate using a protractor and record this on the Excel worksheet.

Compare this experimentally measured value of Brewster’s Angle with one calculated using Brewster’s Law equation.

Here the n is the index of refraction of the glass plate. The glass plate has an index of refraction of approximately 1.5. Calculate this angle on the Excel worksheet.

**Question K:** How well does the angle found experimentally compare to the angle found using the equation?

**Questions for Further Discussion (Number your answers to reflect the numbering of the questions)**

1. Two sheets of polarizing material are placed next to one another, such that their polarizing axes are 90° to each other, and no light passes through the combination. Can you place a third sheet of polarizing material between the two and cause light to pass through this three-sheet combination? If so, explain why this is possible.

2. Polarizing sunglasses are worn to minimize the glare while driving. Which direction would the axis of the polarizing material have to be, in relation to the frames of the sunglasses, to accomplish this? A drawing would be helpful in your description.

3. You were able to partially polarize the light reflected off a plate of glass. What happened to the light which passed through the glass?