

Lab 7 Polarization of Light

Perhaps you have seen a display of polarized sunglasses in a store. You can quickly test to see if the glasses are really polarized by looking through the lenses of two glasses and rotating one pair by 90° . If both pair of glasses are polarized, the lenses will appear to go black. Why is that?

To explain the darkened lenses, we need to think of the light as an electromagnetic wave. An electromagnetic wave has varying electric and magnetic fields perpendicular to the direction the wave is traveling. This experiment focuses only on the electric field variation, represented by a vector. Light emitted from a typical source such as a flashlight is randomly polarized, meaning that the electric vector points in varying directions.

An ideal polarizing filter will remove all but electric fields that are parallel to the axis of the filter. The light remaining is then said to be *polarized*. A second filter can be used to detect the polarization; in this case, the second filter is called an *analyzer*. The transmission through the second filter depends on the angle between its axis and the axis of the first filter. In this experiment you will study the relationship between the light intensity transmitted through two polarizing filters and the angle between the filter axes.

objectives

- Observe the change in light intensity of light passing through crossed polarizing filters.
- Measure the transmission of light through two polarizing filters as a function of the angle between their axes and compare it to Malus's Law.

Materials





Power Macintosh or Windows PC	light source
Light Sensor	polarizing filters (2) with marked axes
LabPro or Universal Lab Interface	
Logger <i>Pro</i>	

Preliminary questions

1. Place one polarizing filter on top of a second so you have to look through both of them. Rotate the top filter until the axis marks are at right angles to one another. What do you notice?
2. Rotate a filter so the axes are now parallel. Look through the stack and rotate the top filter about your viewing axis by 180° . Make a qualitative graph of the transmitted light intensity you

observed as a function of the angle.

Procedures

1. Place the light source, polarizing filters, and Light Sensor so light passes through the filters and then into the sensor. You will rotate only one filter to change the transmission; the other filter, the light source, and the sensor must not move. Turn on the light source.
2. Connect the Light Sensor to Channel 1 of the LabPro. Set the light detector gain switch to 10.
3. Open the Experiment 28 folder from *Physics with Vernier*. Then open the experiment file that matches your type of Light Sensor. Light intensity is plotted vs. analyzer angle. Data will be collected in Event with Entry mode, meaning that the light intensity will only be measured when the button is clicked. You will then type the analyzer angle in degrees and press ENTER to complete the data point.
4. Turn on the light source. Align both polarizers to 0 degrees and adjust the distance from the light source to the polarizers to about 6 cm. Adjust the position of the photometer until the reading on the monitor is 600 lux or less. Record location of all instruments.
5. To zero the photometer adjust the angle of the polarizer on the detector side to 90 degrees. Then slightly adjust the angle of the polarizer on the light source side until you get a minimum reading on the monitor. (You may find it helpful to temporarily remove the photometer from the optic bench and view with your eye through both polarizers as you make this adjustment for a minimum transmitted light, instead of relying on the reading from the monitor). Click the “zero” button on the monitor screen.
6. Return the polarizer on the detector side back to zero degrees. Click  to begin data collection. Click  to take the first point and enter **0** for the angle. Press ENTER to complete the entry.
7. Rotate the analyzer by 10°, click , and enter **10** for the angle. Repeat this process, entering **20** for the next angle, and so forth, until you have rotated the analyzer through one revolution, or 360°. Click  to end data collection.

Analysis

1. Describe your graph of light intensity vs. angle, giving important patterns and points.
2. In the 1800’s Malus proposed

$$I = I_0 \cos^2(\theta)$$

to predict the light transmission through two polarizing filters, where I_0 is the intensity when the angle θ between the polarizer axes is zero.

You can use the Curve Fit feature of *Logger Pro* to superimpose this relationship on your experimental data. Select Curve Fit from the Analyze menu. In the GeneralEquation field of the resulting dialog box select “Define Function”, and in the User Defined Function line enter $I_0 * (\cos(x)^2)$, with I_0 being the numerical value of the maximum intensity from your first data point. In this equation x stands for the angle θ .

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3. Click OK to plot your data and the Malus's law model on the graph at the same time.
5. Compare the data to the model. Are your data consistent with Malus's Law?