

PocketLab Voyager: Polarization and Malus's Law

By Richard Born
Associate Professor Emeritus
Northern Illinois University

Polarization of light is a fascinating phenomenon that gets at the heart of the electromagnetic wavelike nature of light. Polarization is used in sunglasses to help prevent glare, in 3-D movie glasses, in liquid-crystal displays (LCDs) such as those on digital watches and computer screens, in stress analysis tests of transparent plastics, in measuring the concentration of solutions, and in filters for producing beautiful landscape photographs, just to mention a few applications.

One of the most well-known physical laws related to polarization is Malus's Law. This law states that the intensity of plane-polarized light passing through a rotatable polarizer analyzer varies as the square of the cosine of the angle through which the analyzer is rotated from the position giving maximum intensity. As a mathematical equation, the intensity $I = I_0 \cos^2 \theta$. The lesson described here allows you to verify Malus's Law using PocketLab Voyager and one of the light polarizers contained in the PocketLab Scientist Kit.

Hold one of the light polarizers in front of your computer screen and rotate it. Chances are pretty good that you will notice a significant change in light intensity while rotating the polarizer. This means that the light from the computer screen is polarized, and you are using the light polarizer as an analyzer to observe the light from the screen. In order to do a quantitative study of the intensity of the light as you rotate the analyzer, we will use a protractor.

If you do a Google search for "printable protractor", you should be able to obtain a complete circular protractor that you can print on an 8.5 x 11 inch printable plastic transparency sheet. Cut a hole the size of the PocketLab light polarizer in the center of the protractor and then tape the polarizer to the protractor so that the maximum intensity occurs when the protractor shows 0° at the top. You need to cut a **hole** and **replace** it with the polarizer because the plastic sheet material may **unpolarize** the polarized light coming from the computer screen. Figure 1 shows the **back** of the protractor sheet with the light polarizer taped into place. PocketLab Voyager has been taped to the **front** of the plastic sheet with the light sensor opening at the **center** of the circular protractor.

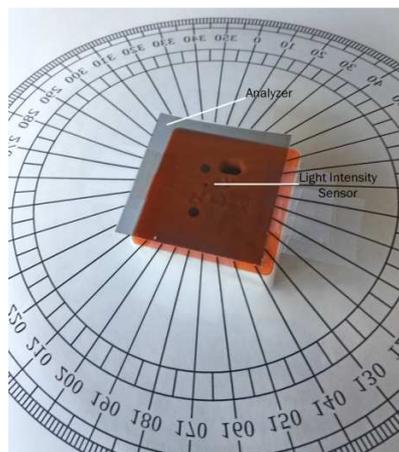


Figure 1

You need a pair of vertical/horizontal crosshairs on your computer screen over which you can rotate the Voyager/protractor assembly. A pdf file with the crosshairs that you can download and open for display on your screen is included with this lesson. Figure 2 shows the assembly held over the computer screen with the angle of rotation θ at 30° .

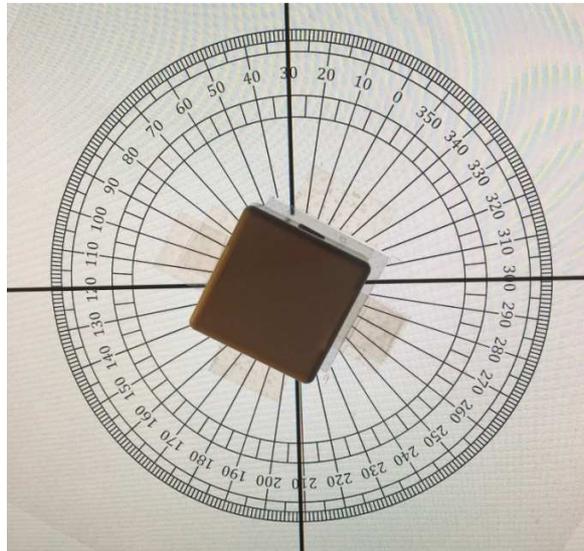


Figure 2

With Voyager having the light intensity sensor selected, start with the angle a 0° . With the assembly held still against the screen, collect data for about 10 seconds. Then move the assembly so that it is rotated to 10° . When the assembly is properly place and still, wait another 10 seconds while continuing to record data. Repeat this process for 10° increments through 360° . The resulting csv file, obtained from the PocketLab app, can be imported into Excel for analysis. Figure 3 shows the resulting graph created from the data in Excel.

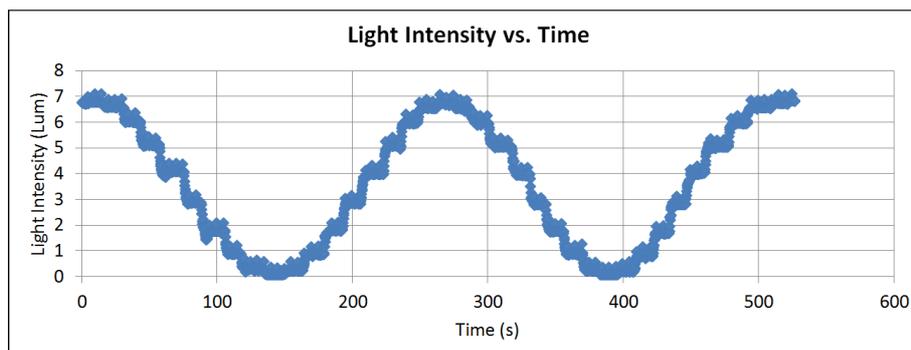


Figure 3

A clearly sinusoidal pattern is evident in the graph. The “plateaus” on the graph represent the roughly 10-second blocks of time where the assembly was held still. The value of the light intensity at each of these plateaus can be read, and a second graph can then be constructed of light intensity vs. angle. See Figure 4 for this graph. (It should be noted that light intensity values (shown in Lux) are about 50 times lower than the actual values. This is due to the fact that this experiment was done during Voyager’s development, prior to the calibration of the light sensor.)

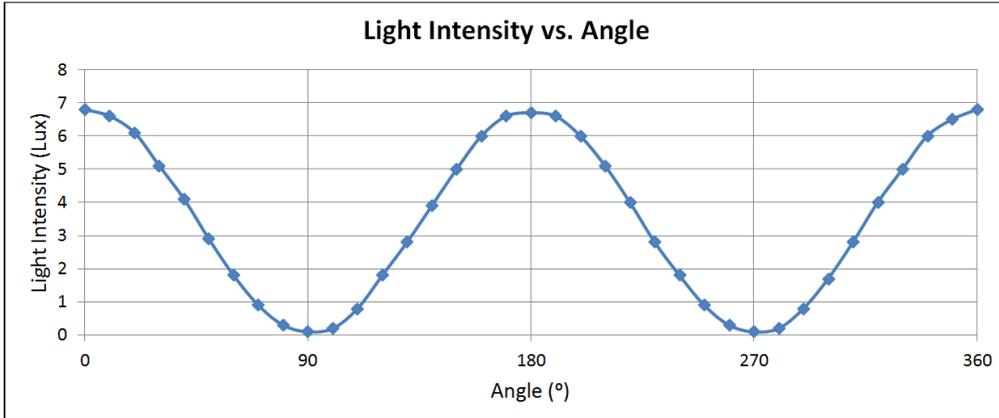


Figure 4

We have verification of Malus's Law! If you have access to Vernier Software & Technology Logger Pro or similar software you can easily do a regression that shows the above graph conforms to a cosine-squared model.