POLARIZATION (1 Lab Period)

Objectives: To confirm Malus's Law: $I(\theta) = I(0) \cos^2 \theta$
To acquire skill at analyzing polarization states of light

References: Hecht, Chapter 8, especially Sections 8.1, 8.2, 8.7 and 8.8

Overview:
These experiments will provide some experience with the phenomenon of polarization. The first experiment, on Malus's Law, is clearly specified in terms of the measurements you should make and how you should plot and analyze the data. The second experiment, on polarization states, has a specific objective, but gives you considerable flexibility in choosing your approach.

Equipment:
Optical rail and riders, or optical table and post-holders, polarized laser, light bulb, pair of linear-polarizing filters (mounted in calibrated rotation holders), $\lambda/4$ retardation plate, laser power meter, various unknown polarization filters.

I. Malus's Law

Preliminary setup:

Place one of the mounted linear-polarizing filters, which we will refer to as the *polarizer*, in front of the laser, and set the polarization angle to 0° (if you have the Edmund polarizing filters) or 90° (if you have the Leybold polarizing filters). The easy-pass direction of the polarizer is now vertical. Turn on the laser power meter, but DO NOT yet place it in the path of the laser beam. Check the reading on the meter, and adjust the zero, if necessary. Set up the laser power meter to receive the transmitted laser beam. Rotate the laser to maximize the reading on the power meter (plane of polarization of the laser is parallel to the *polarizer*). Insert the second linear-polarizing filter, which we will call the *analyzer*, between the *polarizer* and the power meter.

Measurements and analysis:

- Keep the orientation of the polarizer fixed and vary the angle, θ, of the analyzer, with respect to the polarizer, over the range from -90° to +90°.
- Measure the intensity of the transmitted light over this range of angles, and estimate the uncertainty in the measured intensity for each angle.
- Plot the measured intensity, $I(\theta)$. Include error bars on the measured intensity.
- For each value of θ, calculate the predicted intensity according to Malus's Law: $I(\theta) = I(0) \cos^2 \theta$.
- Plot the predicted intensities on the same graph as your measurements. How well does the predicted function fit your data?

II. Polarization States

- In this experiment you will be presented with three "unknown" filters, which will affect the polarization state of the laser in different ways. Note that some filters have two different effects, depending on which side of the filter faces the light source.
- Using the materials and equipment provided, make appropriate observations and measurements to enable you to determine the polarization state produced by each of the filters. Be sure to make observations and measurements for both sides of each filter.
- For each side of each filter, write a convincing argument, based on your measurements, to justify your conclusion about the resulting polarization state. If the filter exhibits a difference in effect, depending on which side faces the light source, how do you account for the observed difference?