Lab 5: Brewster’s Angle and Polarization

I. Brewster’s angle

CAUTION:
- The beam splitters are sensitive pieces of optical equipment; the oils on your fingertips if left there will degrade the coatings on them overtime. *DO NOT PUT FINGER PRINTS ON THE BEAM SPLITTER.*

- The beam splitters are fragile and can scratch easily; you must take care so that this does not happen. *THE BEAM SPLITTERS ARE TO ALWAYS REST ON A KIM-WIPE, DO NOT PLACE THEM ON THE TABLE SURFACE.*

- Above notes also apply loosely to the “D” lens.

- The photosensor will saturate at 5V; be sure that your maximum light intensity is less than 5V. Be sure to zero the sensor before beginning data collection - it is very sensitive and even the light from the computer monitors can throw off your results.

- When the following instructions disagree with the lab manual, follow these instructions.

A. Setup – Spectrophotometer Base

See Step 1 in the lab manual; make sure the side of the aperture bracket closest to the photometer lines up with the 60cm Mark on the optics bench. Make sure the laser is at the other end of the optics bench (~5cm mark).

See Step 2 in the lab manual; take the 180° on the spectrophotometer degree plate to be the 12 O’clock position, the light sensor should be located at the 3 O’clock position.

Follow Steps 3 and 4 in the lab manual; ignore Steps 5 and 6 as you will not be using the rotary motion sensors.

B. Setup – Pivot Plate and Lens Mount

See Steps 1 and 2 in the lab manual.
See Step 3 in the lab manual; make sure that the Brewster’s Angle Accessory plate is screwed in until the notch on it (N) is matched to the 180° mark on the spectrophotometer degree plate (before using the washer & wing nut), once it is centered on the 180° mark use the wing nut to lock it in place. DO NOT SCREW THE BREWSTER’S ANGLE ACCESSORY ALL THE WAY DOWN OR ELSE YOU WILL NOT BE ABLE TO ROTATE THE PHOTOMETER ARM PROPERLY. When you rotate the photometer arm the Brewster’s Angle Accessory plate will remain stationary. Read the note.

See Steps 4 and 5 in the lab manual; the statement “Line up the index mark with the zero degree angle…” refers to the higher step on the lens mount.

**C. Setup – Align the Laser Beam**

Ignore Step 1; you have already done this.

See Step 2 in the lab manual; make sure both photometers are using the #5 aperture for this lab.

See Step 3 in the lab manual; use Slit #5 here and for the collimator.

See Step 4 in the lab manual; the statement “…with the zero mark on the Pivot Plate,” Refers to the Brewster’s Angle Accessory plate, not the spectrophotometer plate.

See Step 5 in the lab manual; you may not want to use the magnetic side of the “D” lens.

Ignore Step 6.

Making the beam splitter holder: take a PASCO lens holder and screw (with the magnetic strip facing up) the L-bracket, which has the words “Component Holder for use with OS-9255A” written on it, into the lens holder. Set this aside, you will need it later.

**D. Setup – Controlling the Laser Intensity**

Ignore Step 1.

Place the second optics bench at a right angle to the first, roughly at the midpoint of the first optics bench. Secure its position with electrical tape.

See Step 2 of the lab manual.

See Step 3 of the lab manual; ignore the statement “Connect a patch cord between…metal on the aperture bracket.” You will be given wiring instructions later.

Ignore the Note; you will be given instructions later. Ignore Steps 4 and 5.

See Step 6 in the lab manual.
Ignore Step 7. Orient the polarizer farthest from the laser to 45° (the 45° mark is not labeled, however its location should be apparent), you will make this alignment by matching the mark with the small notch in the center of the lens holder below the polarizer. Tighten the brass screws so that this polarizer is immobile (i.e. the side with the brass screws should face AWAY from the laser).

Ignore Step 8.

At this time take the beam splitter holder and place it in the first optics bench (that has the aperture bracket and laser on it) so the L-bracket is approximately collinear with the axis of the second optics bench. Orient the spectrophotometer arm so that the 180° on the spectrophotometer degree plate is coincident with the notch on the aperture bracket. Remove the “D” lens momentarily. Align the laser with the adjustment knobs so that the laser is hitting the photosensor aperture at the end of the spectrophotometer (you may have to move the spectrophotometer arm slightly). Place the beam splitter on the beam splitter holder. You will need to adjust the beam splitter until the laser is striking both photosensors (with maximum brightness) on both optic benches. Once the beam splitter is in place and the laser is striking both photosensors, secure its position with electrical tape.

Place back the “D” lens; you may need to adjust the spectrophotometer arm so that the laser is striking the photosensor. Read Both Notes.

**E. Setup – Ignore the sections titled “Sensor Setup” and “Zero the rotary Motion Sensor”**

**F. Setup – Wiring.**

Your TA will provide the wiring scheme; you must include a drawing in your logbook. A photocopy of the drawing must appear in your lab report.

**G. Experimental Procedure**

Ignore Steps 1 and 2.

Make sure the maximum laser light passes through the initial polarizers.

You will be making a table of the following quantities:
1. Reference Photometer Voltage (on the second optical bench)
2. Signal Photometer Voltage, with Analyzer Polarizer, Transmission Axis Horizontal
3. Signal Photometer Voltage, with Analyzer Polarizer, Transmission Axis Vertical
4. Angle on Brewster’s Angle Accessory Plate (Notch)
5. Angle on Spectrophotometer Plate
See Step 3 in the lab manual; you will be using the 85° mark before the 90° mark (i.e. the 85 closest to the laser). Record the Photometer Voltages from the multi-meters, and necessary angles.

Ignore Steps 4 and 5.

See Step 6. Record the Photometer Voltages from the multi-meters, angles will not have changed.

Ignore Step 7.

See Step 8. Record the Photometer Voltages from the multi-meters, angles will not have changed.

Ignore Steps 9 and 10.

See Step 11 (ignoring Steps 7 & 9 again) Step 12.

Ignore Step 13. Ignore – Entering the Data section. Ignore the Analysis section in the lab manual.

H. Analysis

Determine the relative light intensities for all angles. YOU DO NOT NEED TO CONVERT VOLTAGE TO LIGHT INTENSITY. You are only interested in the ratio of Signal over Reference.

Plot the relative light intensity as a function of angle (you may do this in whatever data analysis software is available to you).

Fit the region of your data that has the drop in relative intensity (from start to finish). Your plots should look professional. Proper Labels, Proper Legend, Proper Curve Fits. Equations should be displayed and labeled. Correlation Coefficients should also be shown.

I. Questions

For Question 1: Curve fit your data using a polynomial (your correlation coefficient must exceed 0.95)
   a) How can you compute the minimum?
   b) You must compute the minimum of your experimental data from this equation of fit.

You must answer Questions 3 and 4 using your own data.
Ignore Questions 5-7.
Question 5 Substitute: Compute the degree of Polarization, you may wish to consult Section 8.6 in your textbook.

Question 6 Substitute: Describe the polarized ray created at the Brewster’s Angle in terms of the Jones Vectors; you may wish to consult Section 8.13 in your textbook.

II. Polarization

CAUTION:
- The polarizers are sensitive pieces of optical equipment. 
  DO NOT PUT FINGER PRINTS ON THE POLARIZERS.
- The polarizers are fragile and can scratch easily; you must take care so that this does not happen. 
  THE POLARIZERS ARE TO ALWAYS REST ON A KIM-WIPE, DO NOT PLACE THEM ON THE TABLE SURFACE.
- The photosensor will saturate at 5V; be sure that your maximum light intensity is less than 5V. Be sure to zero the sensor before beginning data collection - it is very sensitive and even the light from the computer monitors can throw off your results.
- When the following instructions disagree with the lab manual, follow these instructions.

A. Setup

See Steps 1 and 2 in the lab manual. Disregard the statement: “and plug the Light Sensor into the interface…”

See Step 3 in the lab manual.

Ignore Steps 4 and 5; you will not be using the rotary motion sensor. See step 6.

You will use 1 polarizer in a PASCO lens holder (with brass screws), orient this so that it is at the zero degree mark, and adjust the screws so the polarizer is fixed.

Place the small polarizer in the Adjustable Lens Holder; orient it at the zero degree mark with the vertical holder.
The wiring for the photosensor is similar to the Brewster’s Angle setup, modify your sketch of the wiring diagram in your logbook, and include a photocopy of this modified diagram in your report.

**B. Procedure for two polarizers**

Ignore Steps 1 and 2. Make sure both polarizers are at the zero degree mark. Ignore Steps 3 and 4.

Starting at zero degrees (with the small circular polarizer in the adjustable lens holder) rotate it in 5-degree increments until a full 180 degrees has been performed, record the voltage from the multi-meter at each increment (along with the angle of the movable polarizer).

When a drastic drop in intensity (voltage) occurs, go back 10 degrees (i.e. before the drop occurred) and make measurements in 1-degree increments until 10 degrees after the voltage drop (after the drop occurred), then continue in 5-degree increments until 180 degrees has been completed. You should record these voltage measurements at each point (along with the angle of the movable polarizer).

**C. Analysis of two polarizers**

Perform Steps 1 and 2 in Excel. Also answer the questions asked in these steps.

**D. Procedure for three polarizers**

You will note be using the rotary motion sensor. Ignore Steps 1 and 2.

Place two polarizers in the PASCO lens holders on the track; orient them so that they are at right angles with respect to each other, fix their positions with the brass screws. Record these angles (it is easiest if you take 0° and 90°).

Ignore step 3.

Place the small polarizer in the adjustable lens holder; place this in between the two polarizers.

Ignore step 4.

Starting at zero degrees (with the small circular polarizer in the adjustable lens holder) rotate it in 5-degree increments until a full 360 degrees has been performed, record the voltage from the multi-meter at each increment (along with the angle of the movable polarizer).

When a drastic drop in intensity (voltage) occurs, go back 10 degrees (i.e. before the drop occurred) and make measurements in 1-degree increments until 10 degrees after the voltage drop (after the drop occurred), then continue in 5-degree increments until 360
degrees has been completed. You should record these voltage measurements at each point (along with the angle of the movable polarizer).

Step 5 is actually a discussion question. Ignore Step 6.

E. Analysis of three polarizers

Repeat Steps 1 and 2 from the two-polarizer case; you are expected to answer the questions again, this time pertaining to 3 polarizers.