PHY385H1F – "Introductory Optics"
Practicals Day 8 – Polarization
November 21, 2011

Group Number (number on Intro Optics Kit): ____.

Facilitator Name:________________________________.

Record-Keeper Name:__________________________________. [Turn this sheet in for marks]

Time-keeper:_____________________________.

Computer/Wiki-master:________________________________.

NOTE: The roles for the above must be *different* than last 2 weeks!

Equipment Needed for Activities 8.1 and 8.2

Optical Bench	Light Source
Polarizers (2)	Components Holders (3)
Ray Table and Base	Ray Table Component Holder
Cylindrical Lens	Viewing Screen
Slit Plate	Slit Mask

Activity 8.1 – Linear Polarizers

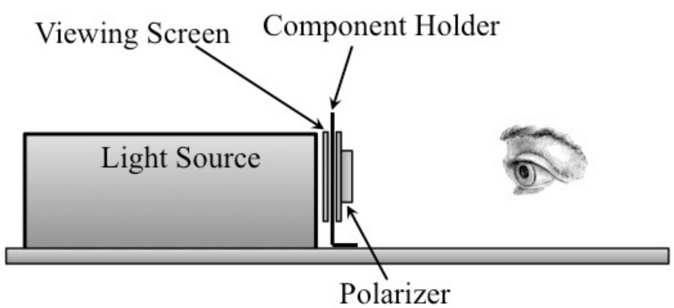

Figure 1.

Set up the equipment as shown in Figure 1. Turn the Light Source on and view the Viewing Screen with the Polarizer removed. Replace the Polarizer on the Component Holder. Rotate the Polarizer while viewing the target. Note that the Polarizer is oriented so that its polarization axis is parallel to the line between 0° and 180°. [These polarizers from PASCO are absorptive filters, also called "Polaroid". According to http://en.wikipedia.org/wiki/Polarizer , Polaroid of this kind…

> "…is made from polyvinyl alcohol (PVA) plastic with an iodine doping. Stretching of the sheet during manufacture ensures that the PVA chains are aligned in one particular direction. Electrons from the iodine dopant are able to travel along the chains, ensuring that light polarized parallel to the chains is absorbed by the sheet; light polarized perpendicularly to the chains is transmitted."

A. Does the viewing screen seem as bright when looking through the Polarizer as when looking directly at the target? Explain your observation and why you observe what you do.

B. Is the light from the Light Source linear polarized? How can you tell?

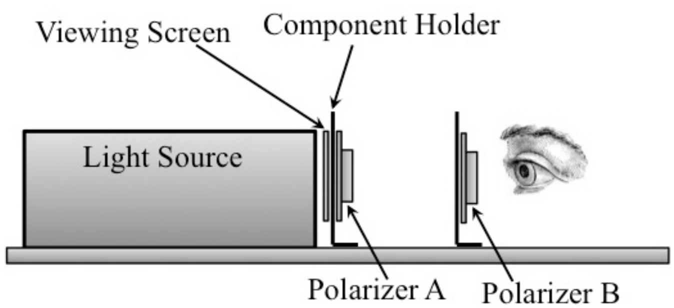

Figure 2.

Now set up the equipment as shown in Figure 2. Note that both polarizers in the box are identical. Align Polarizer A so it transmits only vertically polarized light. Replace Polarizer B on the other Component Holder. Looking through both polarizers, rotate Polarizer B.

C. For what angles of Polarizer B is a **minimum** of light transmitted?

D. For what angles is a **maximum** of light transmitted? When you achieve this maximum, does the target seem as bright when looking through both polarizers as when you remove Polarizer B and look through Polarizer A only?

Activity 8.2 – Linear Polarization by Reflection: Brewster's Angle

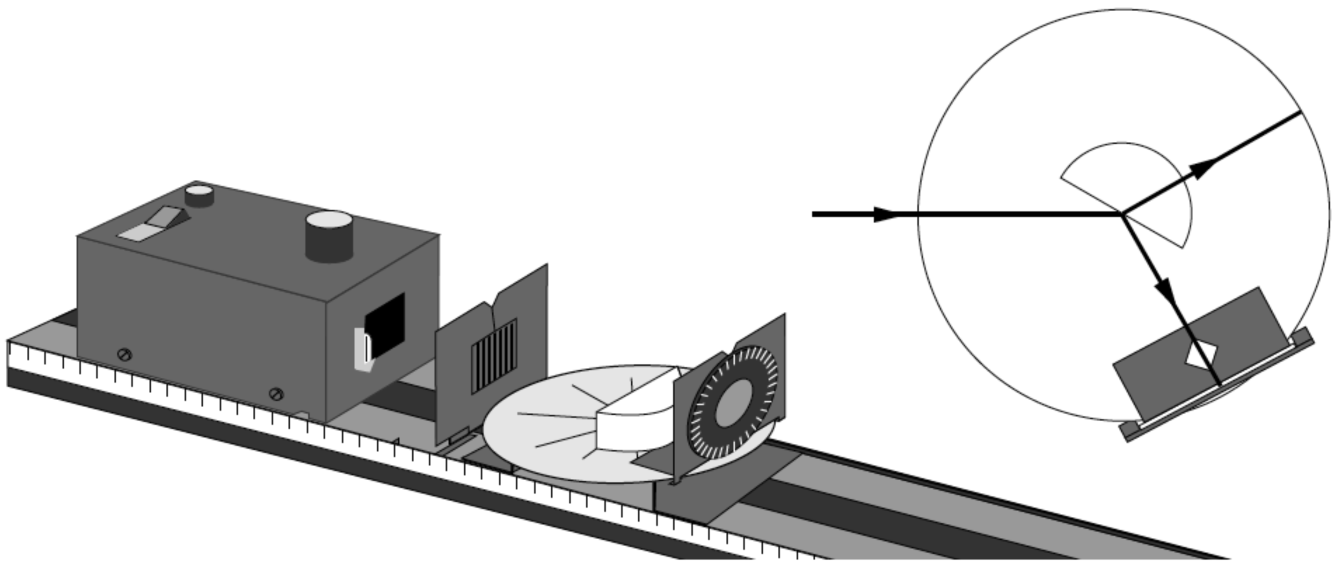

Figure 3.

Set up the equipment as shown in Figure 3. Adjust the Slit Plate, Slit Mask and Ray Table and Base so that a single ray of light passes through the center of the Ray Table. Notice the rays that are produced as the incident ray is reflected and refracted at the flat surface of the Cylindrical Lens. (The room must be reasonably dark to see the reflected ray.)

A. Rotate the Ray Table until the angle between the reflected and refracted rays is 90°. At what angle of incidence θ_i does this occur? Compare with an equation for Brewster's angle from your Hecht text, and estimate the index of refraction of the glass, if you can.

Arrange the Ray Table Component Holder so it is in line with the reflected ray. Look through the Polarizer at the filament of the light source (as seen reflected from the Cylindrical Lens), and rotate the Polarizer slowly through all angles.

B. Is the reflected light linear polarized? If so, at what angle from the vertical is the plane of polarization?

Observe the reflected image for other angles of reflection.

C. Is the light linear polarized when the reflected ray is not at an angle of 90° with respect to the refracted ray?

Activity 8.3 – Some Polarization Definitions

A. Define the following terms:

Linearly Polarized Light

Unpolarized Light

Dichroism

Birefringence

B. Do the polarizers used in activities 8.1 and 8.2 use dichroism or birefringence in order to work?

Activity 8.4 – Malus's Law - Theory

A. Unpolarized light is transmitted through a linear polarizer, whose polarization axis is vertical. The initial irradiance before passing through the polarizer is 1 W/m^2. What is the irradiance exiting the linear polarizer?

B. Linearly polarized light with polarization vector vertical passes through a linear polarizer with an angle of 30° relative to the vertical. The initial irradiance before passing through the polarizer is 0.5 W/m^2. What is the irradiance exiting the linear polarizer?

C. Linearly polarized light with polarization vector 30° relative to the vertical passes through a linear polarizer with an angle of 60° relative to the vertical. The initial irradiance before passing through the polarizer is 0.375 W/m^2. What is the irradiance exiting the linear polarizer?

Activity 8.5 –Real-3D Glasses

In your Intro Optics Kit I have added a lens from a set of Real-3D glasses stolen from a local movie theatre (Cineplex Queensway). On the front I have scratched "L" or "R" depending on whether this was intended to be used for the left or right eye.

Which "eye" do you have in your kit? (Circle one):

L R

My hypothesis is that in 2011, most 3-D movies use circularly polarized light to transmit the images intended for the left and right eye. Use the linear polarizers in your Intro Optics Kit to test:

A. If initially unpolarized light passes through your lens of a Real3-D, does it emerge with linear polarization? If so, is it horizontal or vertical? Be sure the light starts in front of the lens and passes the same way it would normally travel if you were wearing the glasses.

B. If initially horizontally polarized light passes through your lens of a Real3-D, does it emerge with linear polarization? If so, is it horizontal or vertical?

C. If initially vertically polarized light passes through your lens of a Real3-D, does it emerge with linear polarization? If so, is it horizontal or vertical?

D. I hypothesize that Real3-D glasses are made of a quarter waveplate (for most optical wavelengths) followed by a horizontal linear polarizer. Does this make sense with your observations?

Recall:

- Right circularly polarized light has the Electric field vector rotating clockwise when viewed from the $+z$ axis looking down to the origin, when light is traveling in the $+z$ direction. This means that the y-component of E is *advanced* by $\pi/2$ radians relative to the x-component.
- Left circularly polarized light has the Electric field vector rotating counter-clockwise when viewed from the $+z$ axis looking down to the origin, when light is traveling in the $+z$ direction. This means that the y-component of E is *delayed* by $\pi/2$ radians relative to the x-component.

Define the y-axis to be diagonal up and to the left, and the x-axis to be up and to the right, as you are looking forward. The z-axis is coming toward you. As shown in Figure 2, the fast-axis of the quarter wave plate in the left-eye of a set of real 3D glasses is along x. The fast axis for the QWP in the right eye is along y.

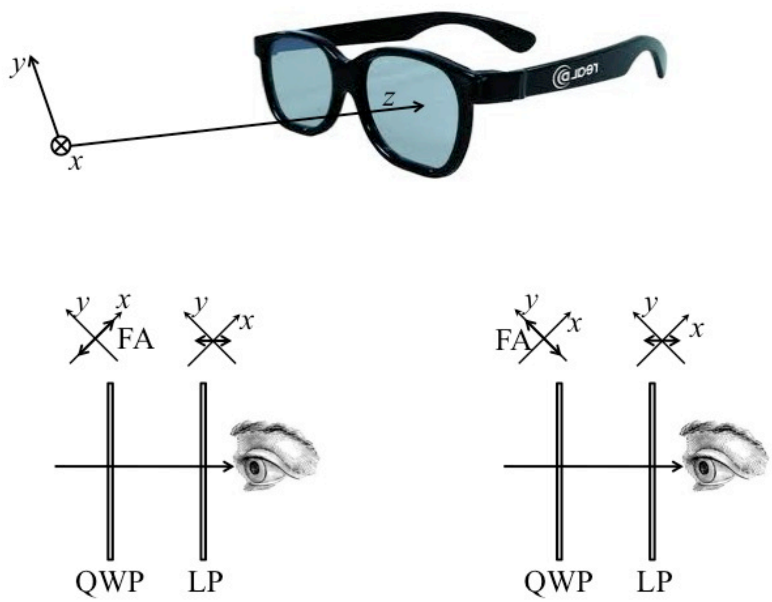

Figure 4.

E. If $\mathcal{R}$-circularly polarized light passes through the left lens of a Real3-D glasses, how will it emerge? What about $\mathcal{L}$-circularly polarized?

F. If $\mathcal{R}$-circularly polarized light passes through the right lens of a Real3-D glasses, how will it emerge? What about $\mathcal{L}$-circularly polarized?

G. Can you use your lens of a Real3-D glasses to produce circularly polarized light? How can you do this? Is it possible to test this? (Niall has an extra L and R lens at the front of the room if you need to borrow one for testing purposes.).