LU06: LAB 1-5C.2: Polarization: Quarter Wave Plate

REFERENCES:

- *Fundamentals of Light & Lasers* (OPTEC), 3rd edition
- Mod 5, Laboratory 1-5C.2, pages 57-58.
  - https://www.youtube.com/watch?v=EBVNbRN8050
- Read these instructions and watch the videos before doing the lab.

THEORY:

A liquid crystal display (LCD) uses polarization to produce images. Liquid crystals are linearly polarized when charged by an electric current. They are sandwiched between two pieces of polarized glass. When they are turned on, they are linearly polarized to block light transmission creating the dark image. Without a charge, the crystals are not linearly polarized so light transmitted through the polarized glass is not blocked so the back of the display is visible.

A ¼ - wave plate changes the polarization of linearly polarized light. The plate has an orientation defined by two axes perpendicular to each other and perpendicular to the optical axis. If one of the axes is aligned with incident linearly polarized light, the light will remain linearly polarized. If the axes are at a 45° angle to the incident light, the light will be circularly polarized. It will be elliptically polarized at other relative angles.

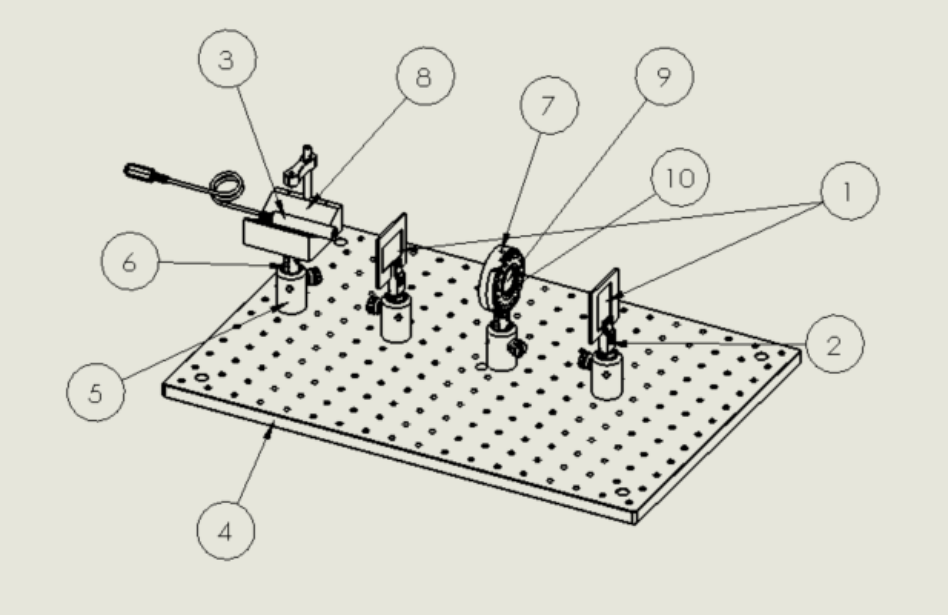
The most common wave plates are ¼ wave and ½ wave. The ½ wave plate rotates the plane of polarization of linearly polarized light 90°. The ¼ wave plate converts linearly polarized light to elliptically or circularly polarized light.

OBJECTIVE:

Use a ¼-wave plate in conjunction with linear polarizers to illustrate the principle of an LCD display.
Complete a comprehensive lab write-up.
Take appropriate pictures (5 or more) to prove/show lab work.

EQUIPMENT:

(2) Polarizer, Slide Mounted (key 1)
(2) Filter Holder (key 2)
Laser Diode Module (key 3)
Laser Diode Power Supply
Optical Plate (key 4)
(4) Post Holder (key 5)
(4) Post (key 6)
Rotation Mount (key 7)
V-Clamp (key 8)
Wave Plate, ¼ Wave (key 9)
Photometer/detector
Misc. Hardware



SET-UP: Read the entire SET-UP and PROCEDURE before starting the lab.

1. Mount 4 post holders in a row of holes along the length of the optical breadboard. Mount one at the left end of the board. Mount another in the fifth hole from the other end and the remaining two equally spaced between them.
2. Mount a post in the center hole on the bottom of the V-clamp and insert the assembly in the post holder at the left end of the board.
   a. Mount the laser diode in the V-clamp
3. Mount filter holders on each of two posts.
   a. Insert one assembly in the post holder closest to the V-clamp and the other in the holder closest to the other end of the board.
4. Place & secure the wave plate in the rotation mount.
   a. Mount a post on the rotation mount and lay the assembly aside.
5. Mount a post on the mirror assembly and lay it aside (will be used in Part 3).

6. Install an observation screen assembly/beam block along the noted row of holes at the end of the plate.

PROCEDURE:

1. Turn on the laser and align it along the noted row of holes with the filter clamp assemblies.
2. Place a polarizer slide in each of the filter clamps. Adjust heights so the beam is centered on the polarizers.
    a. Orient the polarizers so that their transmission axes are perpendicular to each other and **no light/power** is transmitted through polarizer #2 to the screen.
    b. Use photometer/detector with no ambient light to measure power and record ($P_{2plrzrs}$).
3. **Mount the wave plate** assembly in the post holder between the two polarizers.
4. **Rotate the wave plate** so that the light transmitted to the screen is at a minimum power (dimmest light). Use the power meter/detector to measure and record minimum power (P_{min}). This is the **Start Position**.
5. **Note and record** in a data table this position in degrees on the rotational mount.
    a. Does not have to be zero but it will be the "*zero* starting point".
6. Slowly rotate the wave plate to the first position where the light transmitted to the screen is at a maximum power (brightest light). Use the power meter and record P_{max1}. **Record** the degree position of the rotational mount.
7. Continue to rotate the mount a full 360° from the original position (for example, if Start Position was 117°, then End Position should be 117°). Record the position of each **maximum transmission** (there may be more than four). Do this **3 times** to measure & calculate/record averages. More columns will be needed.

Maximum Transmission (mW) at position #	Rotation Mount Position (deg)	Change from Start Position (deg)
$P_{2plrzrs}$	----------	----------
P_{min} (zero or start position)		----------
P_{max1}		
P_{max2}		
P_{max3}		
P_{max4}		
$P_{max.....}$		

CALCULATIONS: Calculate the difference in degrees between the **start position** and the **position of each maximum transmission** to complete the table above.

Include in analysis:

What facts are evident from the data about polarizers, ¼ wave plates, polarization of a laser beam, etc.?

What results did you expect versus the actual results? Compare the two.

From this lab, what was learned about the ¼ wave plate optical component?

There was minimal or no light evident after polarizer #2 but when the ¼ was positioned between polarizer #1 and #2 that changed. Why?