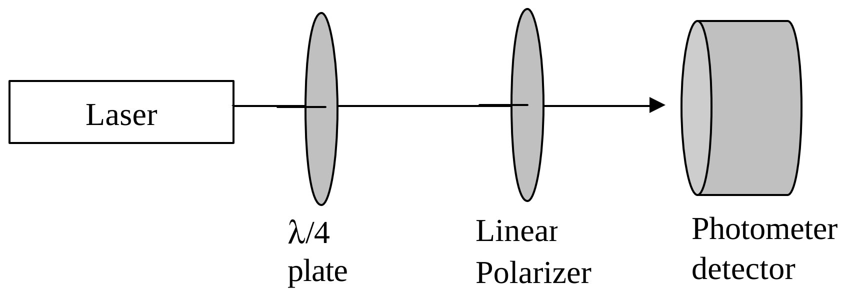
Pre-Lab 11 Physics 342

1). What is the difference between unpolarized light and perfectly circularly polarized light? If you say there is no difference, why do textbooks mention both of these terms? If you say there is a difference, describe an experiment you could perform that would have different results for unpolarized light and circularly polarized light?

2). Suppose we had a material that would retard the electric and magnetic fields of light differently for two different axes. As an example, we will consider what will happen to polarized light as it passes through a material with this property. For this example, assume that the light has the following electric field $\vec{E} = E_0(\hat{x} + i\hat{y})\exp[i(kz - wt)]$ (see pre-lab 9) as it enters the material. The component of the electric field along the axis defined by $\hat{x}$ will be phase shifted by f and will be polarized in the $\hat{x}$ direction after the light exits the material. The component of the electric field along the axis defined by $\hat{y}$ will be phase shifted by $\left(f + \frac{p}{2}\right)$ and will be polarized in the $\hat{y}$ direction after the light exits the material (see pre-lab 10). Describe the polarization before and after the light exits the material.

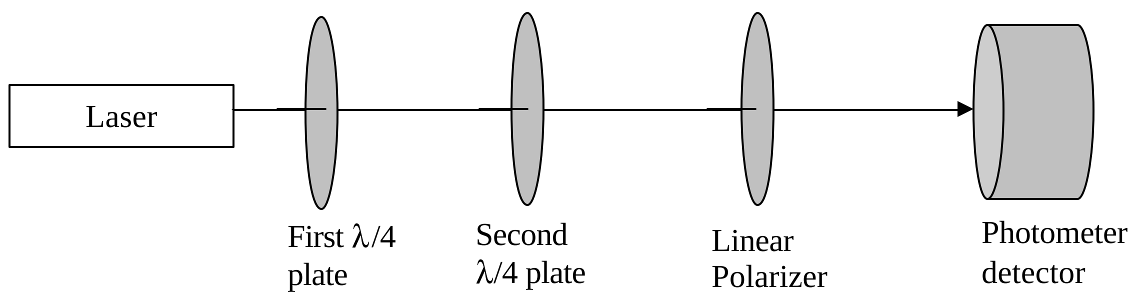
Lab 11

Attach a linear polarizer to a rotator. Turn a linear polarizer to the angle that minimizes the light from a He-Ne laser reaching a photometer (without any other polarizing devices present). We will call this angle 0°. Set up the equipment as shown below.



First turn the linear polarizer to its zero location (where it minimized the light from the laser). Next, rotate the λ/4 – plate to minimized the light power at the photometer. We will call this 0° for the λ/4 – plate and we will keep this definition throughout the rest of the investigation.

Connect a second λ/4 – plate to a plate rotator. Set up the equipment as shown below.



First turn the linear polarizer to its previous zero location (where it minimized the light from the laser). Next, rotate the first λ/4 – plate to its previous zero location. Now rotate the second λ/4 – plate to minimize the light power reaching the photometer. We will call this 0° for the second λ/4 – plate and we will keep this definition throughout the rest of the investigation. Add a small piece of masking tape to the second λ/4 – plate's rotator so that you can distinguish your two λ/4 – plates.

Now rotate the first λ/4 – plate to 45°. What is the best description of the polarization (linear, elliptical, circular) between the first and second λ/4 – plates? How do you know?

CHECK WITH YOUR INSTRUCTOR BEFORE CONTINUING.

Rotate the linear polarizer and the second λ/4 – plate to minimize the light power reaching the photometer. Keep rotating these two devices until you nearly extinguish the laser light reaching the photometer.

Predict how the light power reaching the photometer will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. the linear polarizer's angle.

Explain your reasoning for the above sketch:

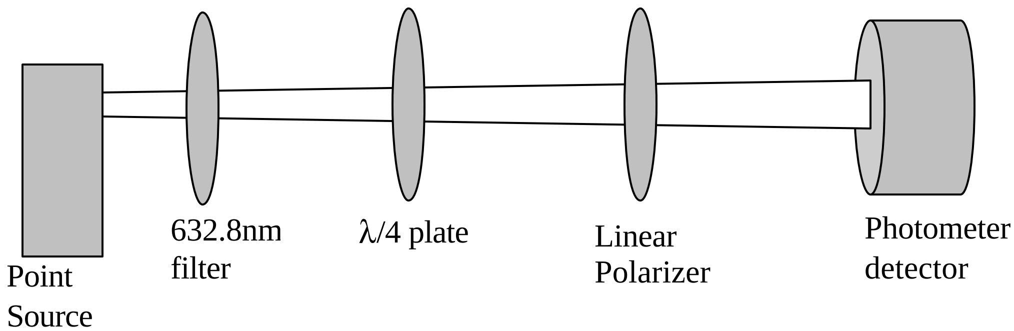
Rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results (make sure that zero power is on the graph). Compare to your predictions. Resolve any differences.

$\theta = 0°$		$\theta = 120°$		$\theta = 240°$	
$\theta = 15°$		$\theta = 135°$		$\theta = 255°$	
$\theta = 30°$		$\theta = 150°$		$\theta = 270°$	
$\theta = 45°$		$\theta = 165°$		$\theta = 285°$	
$\theta = 60°$		$\theta = 180°$		$\theta = 300°$	
$\theta = 75°$		$\theta = 195°$		$\theta = 315°$	
$\theta = 90°$		$\theta = 210°$		$\theta = 330°$	
$\theta = 105°$		$\theta = 225°$		$\theta = 345°$	

How is the light elliptically polarized? Draw a sketch that shows the eccentricity and the tilt angle of the elliptical polarization.

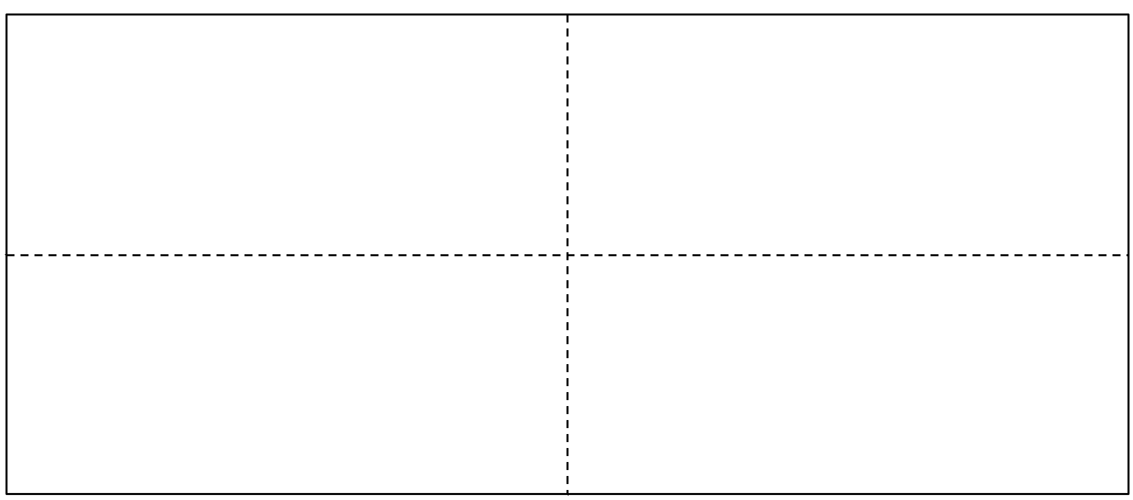
Quarter wave plates are useful in transforming one form on elliptical polarization into another. Quarter wave plates can transform linear polarization into elliptical polarization and elliptical polarization into linear polarization. If one had perfectly circular polarized light ($e = 0$), one would find that a linear polarizer always cuts the intensity in half no matter its angle. This is the same relation one would have for unpolarized light. Is there a difference between unpolarized light and circularly polarized light? Come up with a group consensus.

Using a point source (which is unpolarized) and the 632.8nm light filter (held with either a plate rotator or lens mount) construct the below set up. For our λ/4 – plates to work properly, we need to use a monochromatic beam with wavelength 632.8nm. A 632.8nm light filter removes all wavelengths other than 632.8nm from a white light source. Since the beam is spreading out, try to keep all the components as close together as possible.



Try to minimize the light reaching the photometer by rotating the λ/4 – plate and the linear polarizer. Keeping rotating the λ/4 – plate and the linear polarizer until you are sure you cannot make the beam and dimmer.

Predict how the light power reaching the photometer will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. the linear polarizer's angle.



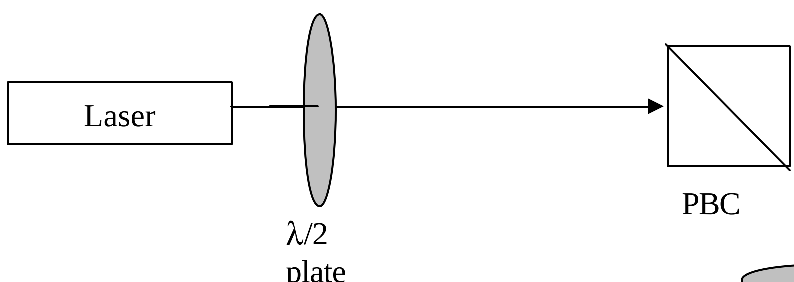
Explain your reasoning for the above sketch:

Rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results (make sure that zero power is on the graph). Compare to your predictions. Resolve any differences.

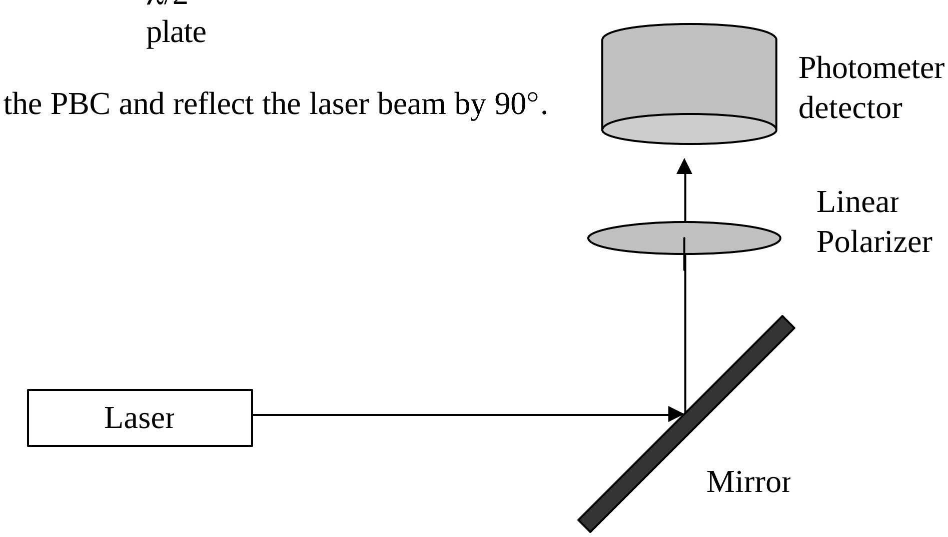
θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

Is the light coming through the first 632.8nm filter polarized (as opposed to unpolarized)? Explain your reasoning.

Adjust a λ/2 – plate so that half of the light is transmitted and half the light is reflected by a PBC.



Next, remove the PBC and reflect the laser beam by 90°.



Predict the shape of a plot of the transmitted laser beam power vs. the linear polarizer's rotation angle.

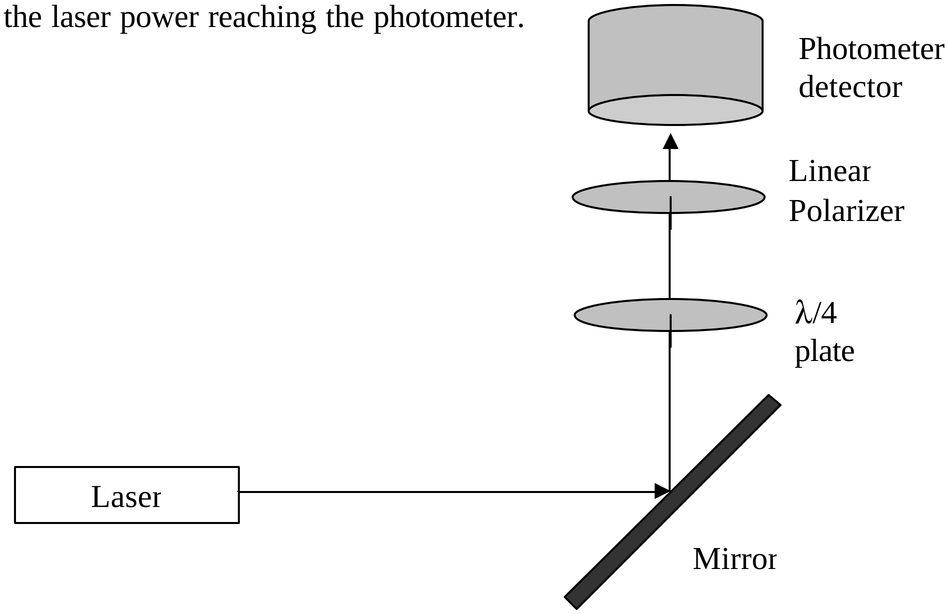
Explain your reasoning for the above sketch:

Now set up the above condition and test your predictions. Complete the table and then using Excel plot your results (make sure that zero power is on the graph). Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

How is the light elliptically polarized? Draw a sketch that shows the eccentricity and the tilt angle of the elliptical polarization.

Next, add a λ/4 plate as shown below. Repeatedly rotate the linear polarizer and λ/4 plate to minimize the laser power reaching the photometer.



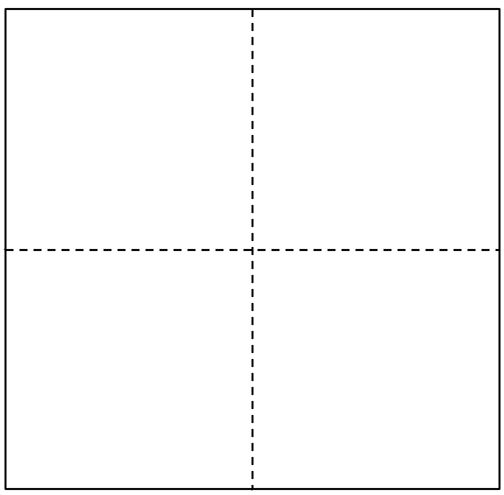
Predict the shape of a plot of the transmitted laser beam power vs. the linear polarizer's rotation angle.

Explain your reasoning for the above sketch:

Now set up the above condition and test your predictions. Complete the table and then using Excel plot your results (make sure that zero power is on the graph). Compare to your predictions. Resolve any differences.

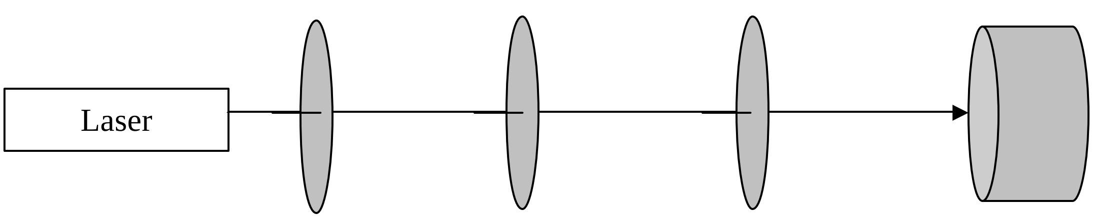
θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

How is the light elliptically polarized? Draw a sketch that shows the eccentricity and the tilt angle of the elliptical polarization.



Is the light reflected off a mirror polarized? How can you tell?

Set up the equipment as shown below.



First turn the linear polarizer to its previous zero location (where it minimized the light from the laser). Next, rotate the first $\lambda/4$ – plate to 22°. Finally, rotate the $\lambda/2$ – plate to 0°. Predict how the light power reaching the photometer will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. the linear polarizer's angle.

Explain your reasoning for the above sketch:

Rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results (make sure that zero power is on the graph). Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

How is the light elliptically polarized? Draw a sketch that shows the eccentricity and the tilt angle of the elliptical polarization.

Now rotate the $\lambda/2$ – plate to 45°. Predict how the light power reaching the photometer will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. the linear polarizer's angle.

Explain your reasoning for the above sketch:

Rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results (make sure that zero power is on the graph). Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

How is the light elliptically polarized? Draw a sketch that shows the eccentricity and the tilt angle of the elliptical polarization.

In general, what does a $\lambda/2$ – plate do to polarized light?